

24 September 2018
66-ZB-H200-ASI-19064

Brian Murphy
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[REDACTED]



Subject: Boeing EQA Report on Slats, Passenger Windows, Fuselage, and Fan Cowl
Fragment - Southwest Airlines 737-700 N772SW Engine Failure and
Decompression Philadelphia, 17 Apr 2018

Dear Mr. Murphy:

In support of the NTSB investigation into the subject event, Boeing's Equipment Quality Analysis (EQA) laboratory performed an examination of the left wing outboard leading edge slats, three passenger windows, as well as several fragments of fuselage and fan cowl structure removed from the accident airplane. In addition, an analytical chemical analysis was performed on residue samples collected during the field phase of the investigation and a material analysis was also performed on several metallic fragments and contaminants collected during the EQA examination. Please find both the Equipment Quality Analysis (EQA) and chemical analysis lab reports enclosed with this letter.

The information included with this correspondence is controlled under the US Export Administration Regulations (15 CFR Parts 300-799) and has been categorized as ECCN: 9E991.

Please feel free to contact us if you have any questions.

Best regards,

[REDACTED]

Robert J. McIntosh
Director, Product Safety

Enclosure: Boeing EQA Report AS12821

cc: Bill English, Investigator-In-Charge, NTSB



Equipment Quality Analysis Report

Boeing Commercial Airplanes



TO: Air Safety Investigation (ASI) **EQA NUMBER:** AS12821
DATE: September 20, 2018
MODEL NUMBER: 737-700
AIRPLANE NUMBER: YA070

SUBJECT: ***Examination of Damaged Components Removed from Southwest Airlines (SWA) Aircraft YA070***

IDENTIFICATION:

Part name:	Window Assembly, Passenger
Boeing part number (P/N):	140N2139-1
Serial number (S/N) (middle pane):	S061535131, S061535129, S061535128
Supplier:	GKN Aerospace
Date code:	1Q15
Part name:	Fuselage Skin Fragment, Aft (Row 24)
Supplier:	Spirit Aerosystems
Part name:	Fuselage Skin Fragment, Aft (Row 14)
Supplier:	Spirit Aerosystems
Part name:	Fan Cowl Fragment, L/H Engine, Inboard
Supplier:	UTC Aerospace Systems (UTAS)
Part name:	Inlet Cowl Fragment
Supplier:	UTAS
Part name:	Slat Assembly, No. 1
Boeing part number:	114A5010-3
Serial number:	000536
Supplier:	Spirit Aerosystems
Part name:	Slat Assembly, No. 2
Boeing part number:	114A5020-3
Serial number:	000613
Supplier:	Spirit Aerosystems

IDENTIFICATION: Part name: Slat Assembly, No. 3
(Continued) Boeing part number: 114A5030-3
Serial number: 000616
Supplier: Spirit Aerosystems

Part name: Slat Assembly, No. 4
Boeing part number: 114A5040-5
Serial number: 000609
Supplier: Spirit Aerosystems

REFERENCES: (a) National Transportation Safety Board (NTSB) Accident No:
DCA18MA142

BACKGROUND:

Per reference (a), on April 17, 2018, a SWA 737-700, N772SW (YA070), experienced a failure of the number one engine at approximately 32,000 feet en route from New York to Dallas. The majority of the engine cowl inlet, and outboard fan cowl as well as a portion of the inboard fan cowl departed from the left engine. Fragments of the cowlings are believed to have impacted the left wing, left horizontal stabilizer, fuselage, and a cabin window (row 14) resulting in cabin depressurization. The aircraft diverted and landed in Philadelphia.

Per reference (a), it was reported that the number 13 fan blade had separated at the root, with the fan blade dovetail remaining in the fan disk. It was found that the remaining dovetail exhibited features which appeared to be consistent with metal fatigue.

Aircraft YA070 was delivered on July 7, 2000, and was reported to have accumulated 63,522 hours and 37,031 cycles as of April 18, 2018. Per reference (a), it was reported that the failed engine had accumulated more than 32,000 engine cycles since new, and the fan blades were last overhauled 10,712 cycles before the failure.

Multiple parts from aircraft YA070 were sent to the Boeing Equipment Quality Analysis (EQA) facility in Seattle, WA for examination, which included:

- Three passenger window assemblies, rows 22, 23, and 24 from the left side of aircraft
- Two sections of damaged fuselage skin, one section of skin was removed from above the row 24 window, and the other section of skin was removed from below the row 14 window
- A fragment of the number one engine inboard fan cowl
- A suspected fragment of the inlet cowl assembly, removed from the fixed leading edge of the left wing
- All four leading edge slats from the left wing

SUMMARY:

The examination of the preceding parts took place on May 20 & 21, 2018. Representatives from the Federal Aviation Administration (FAA), NTSB, SWA, UTAS, GKN Aerospace, and Boeing were present. All actions taken by Boeing were at the direction of the NTSB, with the consensus of the attending parties.

Nine samples of grease-like substances were taken during the initial damage assessment of the aircraft in Philadelphia. Under the direction of the NTSB, the samples were delivered to Boeing Research and Technology (BR&T), Puget Sound Analytical Chemistry group for comparative analysis. BR&T was able to determine that all nine samples were virtually identical to each other. See enclosure A for more details.

Of the three passenger window assemblies received, only the row 24 window appeared to have sustained impact damage. The row 22 and 23 exterior window panes had witness marks, which consisted of an unidentified material that had been deposited on the surface of the pane. Per discussion and agreement between all parties present during the examination, the NTSB directed that the windows be delivered to BR&T for material identification of the witness marks on the row 22 and 23 windows, and to check for any residual foreign material in the damage of the row 24 window, with the understanding that destructive analysis may be required. BR&T found traces of aluminum in the damaged area of the row 24 window and on the witness mark of the row 22 window. The aluminum fragments most closely match 7000 series aluminum, but an exact match was not possible due to the small particle size. The material on the row 23 window had no trace evidence of aluminum, but carbon, oxygen, silicon, and sulfur were detected. See enclosure A for more details.

The skin section removed from approximately two feet above the row 24 window had an impact mark approximately 4.7 inches in length and 0.05 inch in width, which penetrated the skin. Per discussion and agreement between all parties present during the examination, the NTSB directed that the row 24 skin section be delivered to BR&T to check for any residual foreign material in the damaged area, with the understanding that destructive analysis may be required. BR&T did not find any residual foreign material in the damaged area of the skin. Only trace amounts of primer were present. See enclosure A for more details.

The skin section removed from approximately two feet below the row 14 window had a puncture in between the two rows of removed fasteners. There were also multiple scrapes and scratches in various locations on the exterior surface of the skin section. A grease-like substance was found on the surface of the exterior skin, which had been previously sampled during the initial damage assessment in Philadelphia and was part of the nine samples that were provided to BR&T. See enclosure A for more details.

The left engine inboard fan cowl fragment, which had departed the aircraft and was recovered on the ground, showed evidence of impact damage. The fragment was determined to be from the lower aft corner of the inboard fan cowl.

The suspected engine inlet cowl fragment was found embedded in the skin of the left wing, aft of the number two slat. Under direction from the NTSB, the fragment was delivered to BR&T for material analysis. The BR&T analysis showed that fragment most closely matches 2000 series aluminum. See enclosure A for more details.

The majority of the damage found on all four of the slats was on and around the leading edge. All four of the slats had scratches and gouges which were consistent with an object sliding down the leading edge of the slats from inboard to outboard. Three of the four slats also had evidence of impact damage on the leading edge. Slat No. 3 had two metal fragments that were liberated from it. The larger fragment was reportedly removed from a damaged area of slat No. 3 during the initial damage assessment of the aircraft in Philadelphia, and the smaller fragment was found during the examination at the EQA facility, on the interior of the leading edge. The NTSB directed that both of the metal fragments associated with slat No. 3 be delivered to BR&T for material analysis. The BR&T analysis concluded that both the large and the small fragments most closely matches 7000 series aluminum. See enclosure A for more details.

EXAMINATION:

Two boxes containing several items from YA070 were delivered to EQA on May 3, 2018, by the NTSB; see Figure 1.



Figure 1: Overview of the two boxes received

One of the boxes contained nine samples which were collected from the aircraft during the initial damage assessment in Philadelphia, soon after the event. It was requested that the samples be removed from the box and passed on to BR&T for comparative analysis. Under the direction of the NTSB and with an NTSB representative in attendance on May 3, 2018, the box containing the samples was opened, and the samples were delivered to BR&T that same day. An overview of the sample containers is shown in Figure 2.



Figure 2: Nine samples that were given to BR&T

The BR&T analysis of the samples concluded that all nine samples were all comprised of the same compound. See enclosure A for more details.

Everything that was removed from the box, to gain access to the samples, was placed back into the box. The box was then sealed and both boxes secured in a NTSB controlled storage room until the day of the examination, which took place on May 20 & 21, 2018.

Windows

An overview of the box that the window assemblies arrived in is shown in Figure 3. The box was labeled 2 of 2.



Figure 3: Box containing the window assemblies

The window assemblies were removed from the box and inspected individually. An overview of the row 24 window assembly is shown in Figure 4.

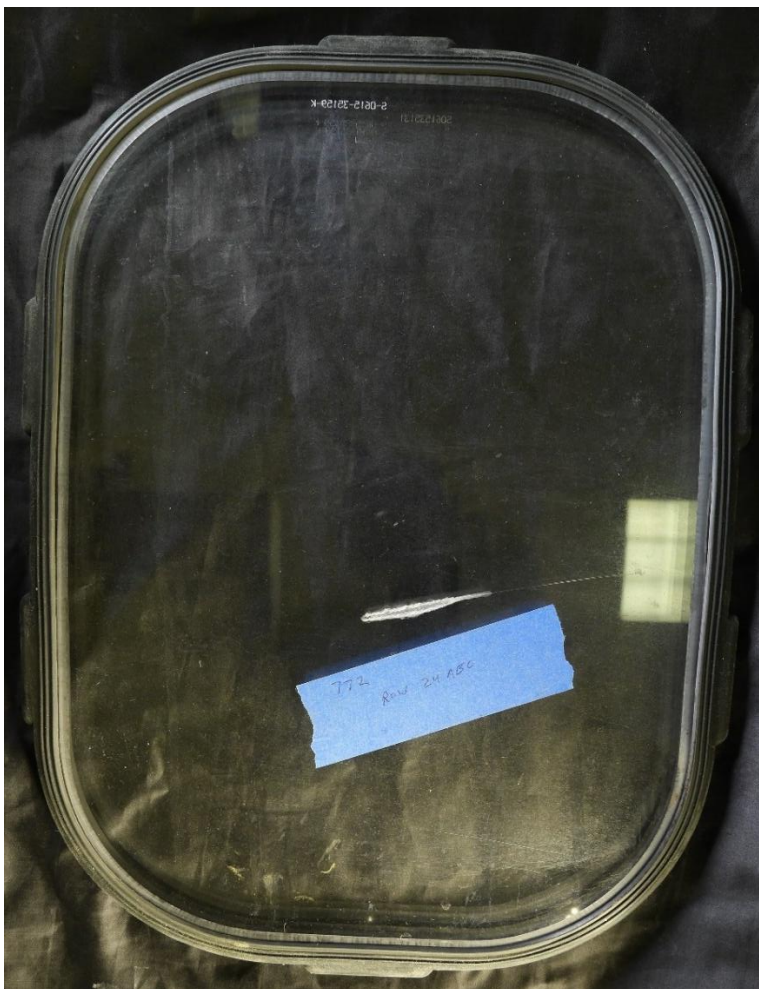


Figure 4: Overview of window assembly from row 24

The P/N 65-45792-6 and S/N S061535131 of the row 24 window assembly middle pane are shown in Figure 5.

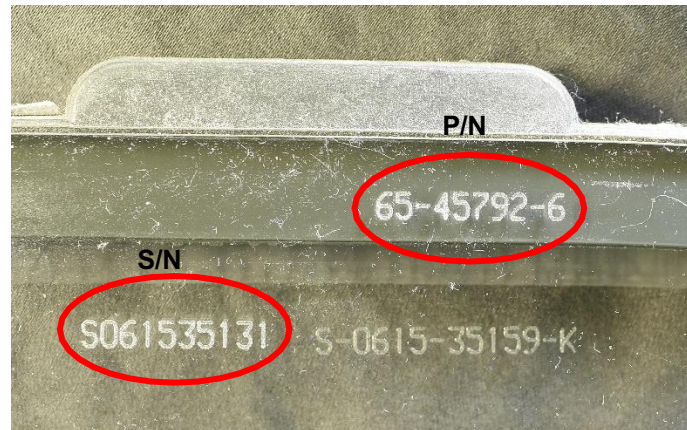


Figure 5: P/N and S/N of the middle pane of the row 24 window assembly

The outer pane of the window assembly had a gouge located near the center that measured approximately 2.2 inches in length and 0.23 inch in width. A magnified view of the gouge is shown in Figure 6.



Figure 6: Gouge in row 24 window

Under direction of the NTSB, the outer pane of the row 24 window was removed from the assembly and sent to BR&T to check for any residual foreign material in the damaged area; see Figure 28.



Figure 7: Row 24 window assembly disassembled

An overview of the row 23 window assembly is shown in Figure 8.

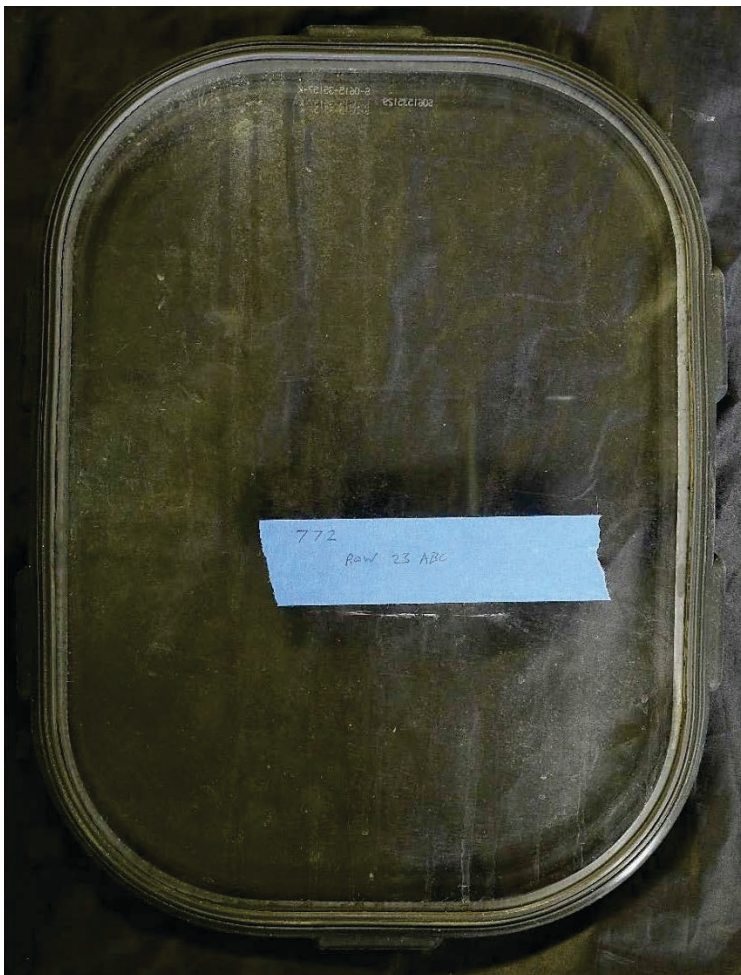


Figure 8: Overview of row 23 window assembly

The P/N 65-45792-6 and S/N S061535129 of the row 23 window assembly middle pane are shown in Figure 9.

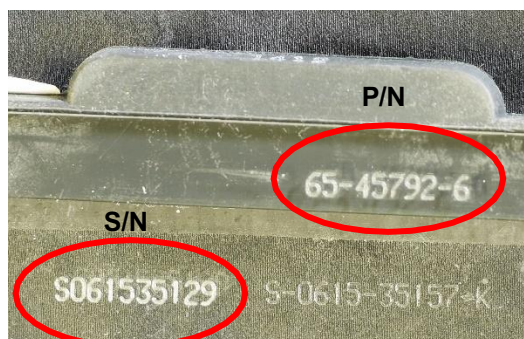


Figure 9: P/N and S/N of the middle pane of the row 23 window assembly

A witness mark was noted on the outer pane of the row 23 window assembly that measured approximately 2.6 inches in length and 0.1 inch in width. The mark appeared to be foreign material that was deposited onto the window pane; see Figure 10.



Figure 10: Witness mark on outer pane of row 23 window

Under direction of the NTSB, the outer pane of the row 23 window was removed from the assembly and sent to BR&T for material identification of the witness mark; see Figure 11.

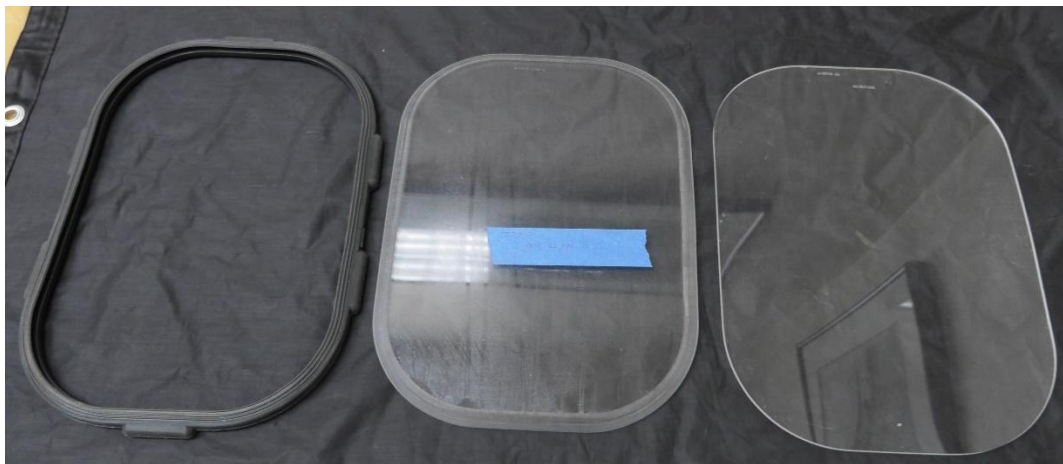


Figure 11: Row 23 window assembly disassembled

An overview of the row 22 window assembly is shown in Figure 12.

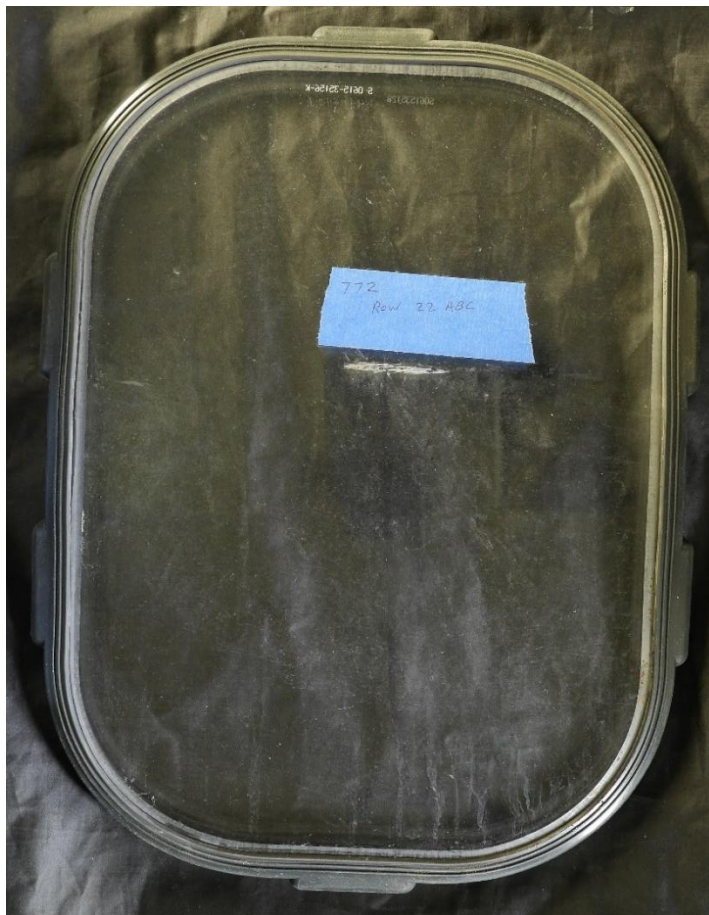


Figure 12: Overview of row 22 window assembly

The P/N 65-45792-6 and S/N S061535128 of the row 22 window assembly middle pane was shown in Figure 13.

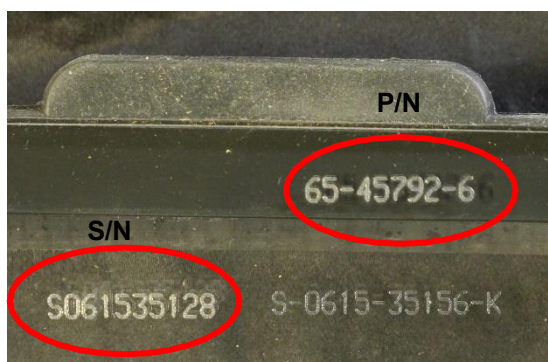


Figure 13: P/N and S/N of the middle pane of the row 22 window assembly

A witness mark was noted on the outer pane of the row 22 window assembly. The most prominent portion of the witness mark measured approximately two inches in length and 0.1 inch in width. The mark appeared to be foreign material that was deposited onto the window pane; see Figure 14.

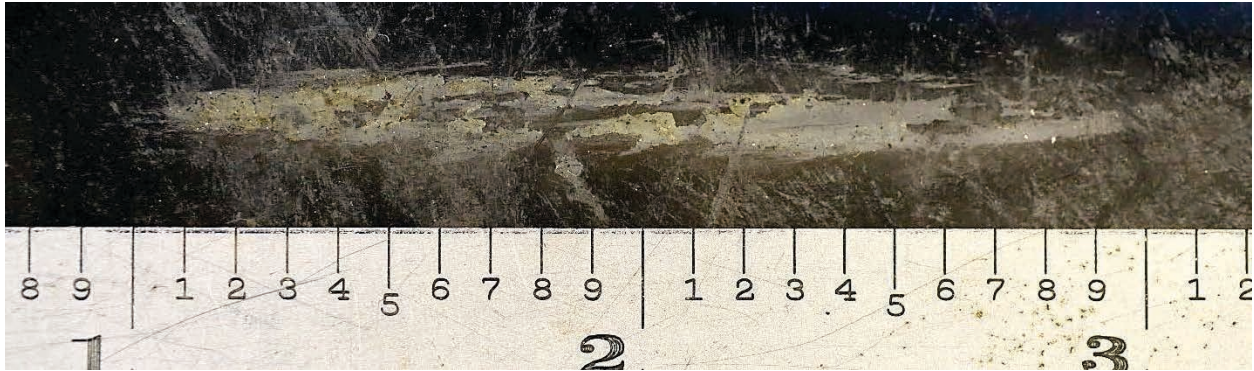


Figure 14: Witness mark on outer pane of row 22 window

Under direction of the NTSB, the outer pane of the row 22 window was removed from the assembly and sent to BR&T for material identification of the witness mark; see Figure 15.



Figure 15: Row 22 window assembly disassembled

Fuselage Skin Fragments

The two fuselage skin sections were included in the same box as the three passenger window assemblies.

An overview of the fuselage skin section that was reportedly removed from approximately two feet above the left hand row 24 passenger window is shown in Figure 16.



Figure 16: Overview of row 24 skin section

The skin section was approximately 7.7 inches in length and 2.9 inches in width. It featured a gouge in the approximate center, which measured 4.7 inches in length and 0.05 inch in width at its widest point; see Figure 17.



Figure 17: Gouge in row 24 skin section

The depth of the gouge was enough to fracture the inner surface of the skin; see Figure 18.

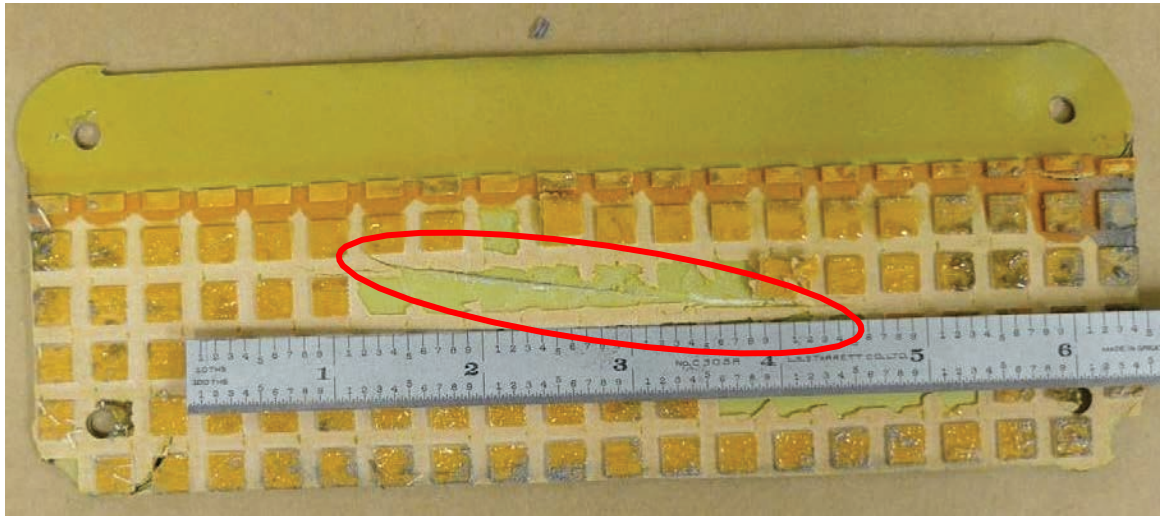


Figure 18: Inner surface of row 24 skin section, showing gouge penetration

Under direction of the NTSB, the row 24 skin section was sent to BR&T to check for any residual foreign material in the damaged area.

An overview of the section of fuselage skin that was reportedly removed from approximately two feet below the left hand row 14 passenger window is shown in Figure 19. The skin section measured approximately 11.5 inches in length and 5.75 inches in width.

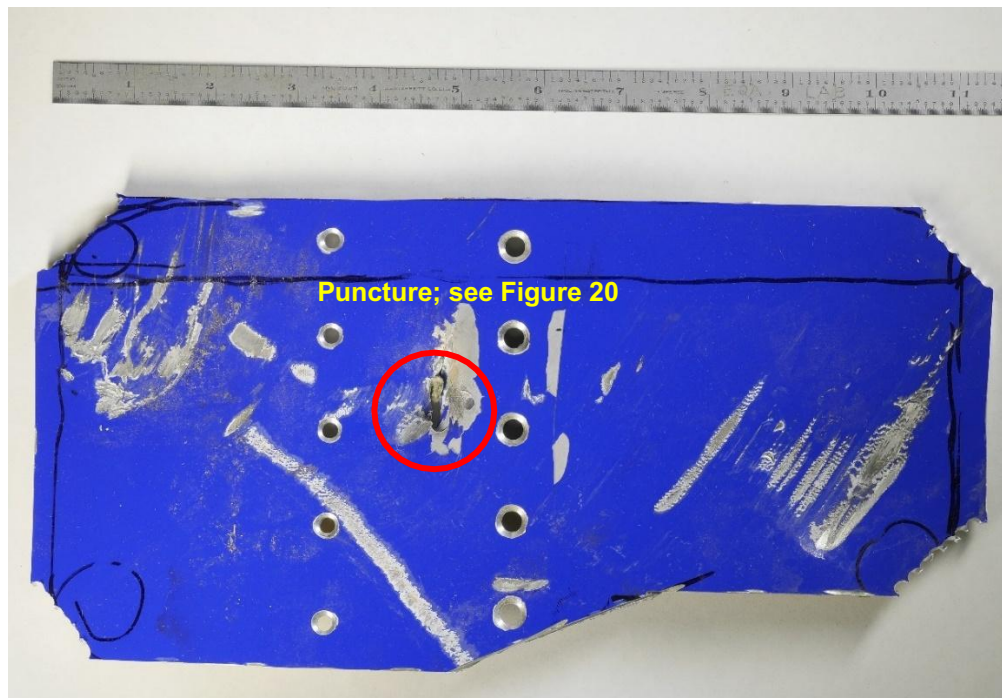


Figure 19: Overview of row 14 skin section

Multiple scratches were found along the surface of the skin section. A puncture was also observed in approximately the center of the skin section; see Figure 20.

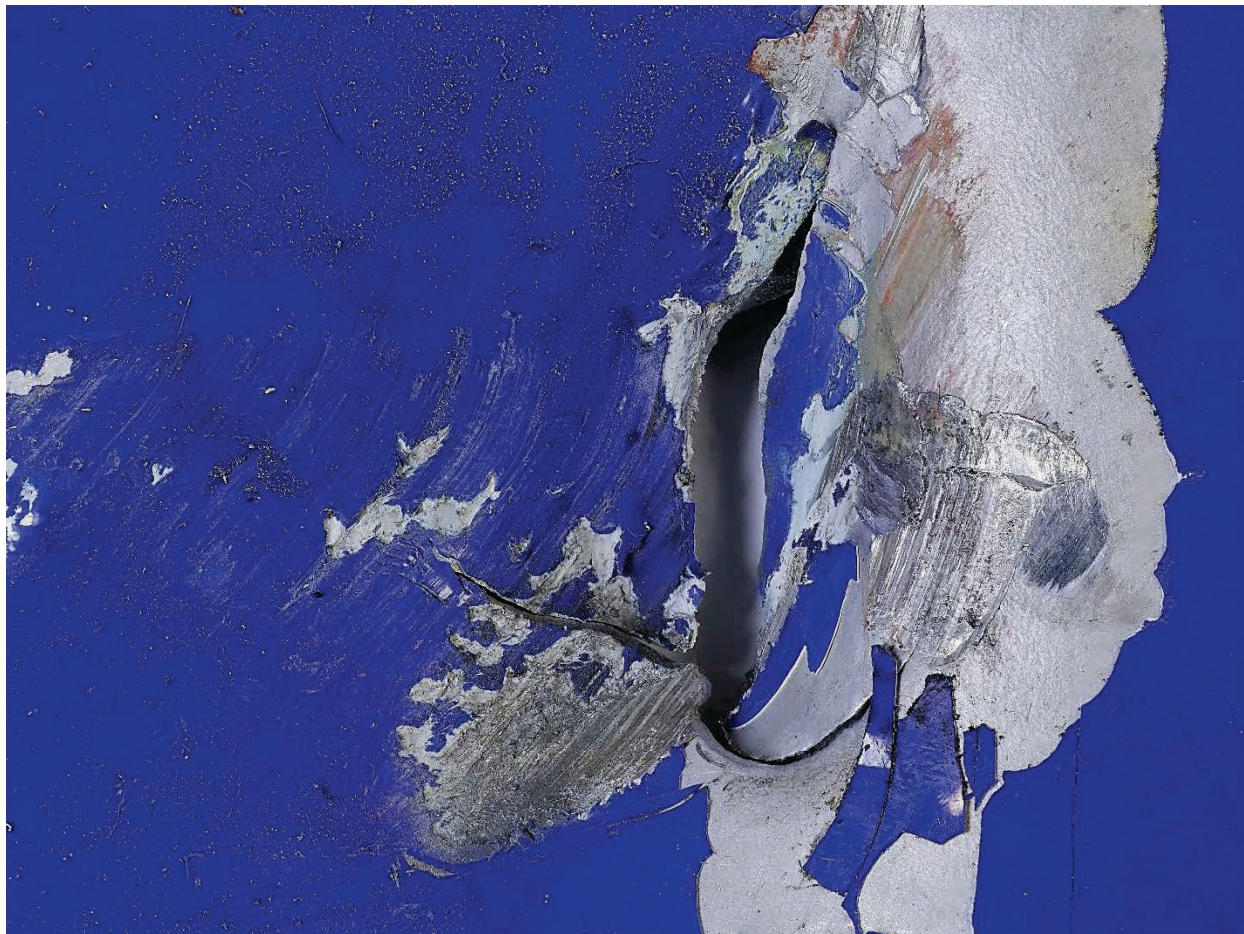


Figure 20: Puncture located in center of row 14 skin section

Inboard Fan Cowl Fragment

An overview of the box that the inboard fan cowl fragment arrived in is shown in Figure 21. The box was labeled, 1 of 2.



Figure 21: Box containing the fan cowl fragment

The inboard fan cowl fragment was reportedly recovered from the ground beneath the approximate flight path of the subject aircraft. The fragment measured roughly 22 inches in length and 13 inches in width, and was identified as the lower aft corner of the inboard fan cowl. Overviews of the inboard fan cowl fragment are shown in Figure 22 and Figure 23.

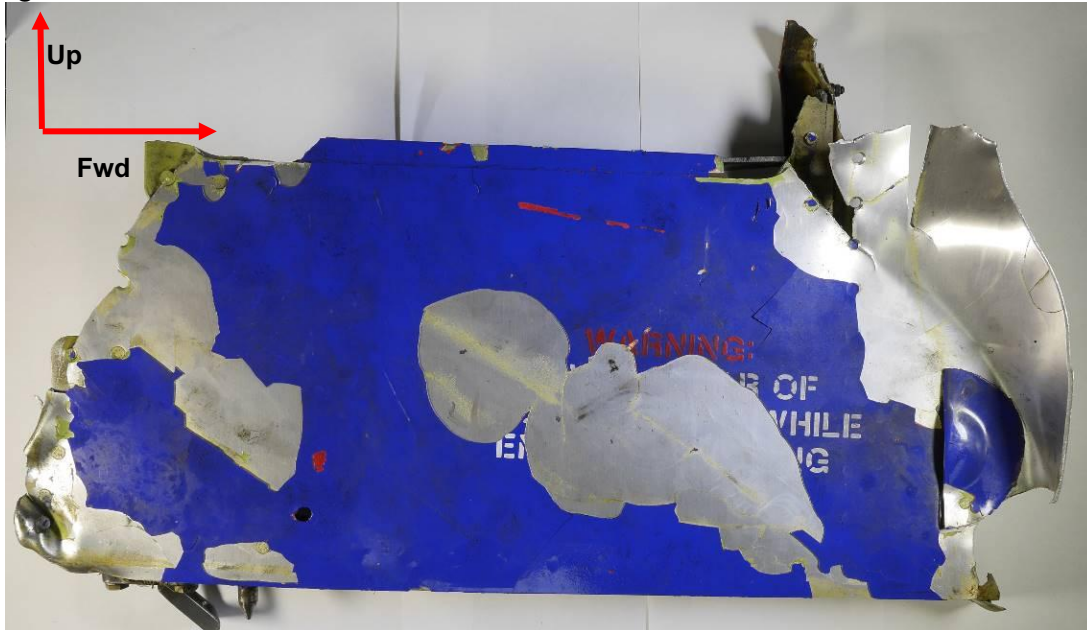


Figure 22: Exterior overview of fan cowl fragment



Figure 23: Interior overview of fan cowl fragment

The aft latch keeper, on the lower aft corner of the cowling fragment was found bent forward, with grass and soil remaining on the surface. There was also damage found on the aft edge of the internal portion of the latch keeper base, opposite the direction the bent latch keeper was found. The aft latch keeper is shown in Figure 24.

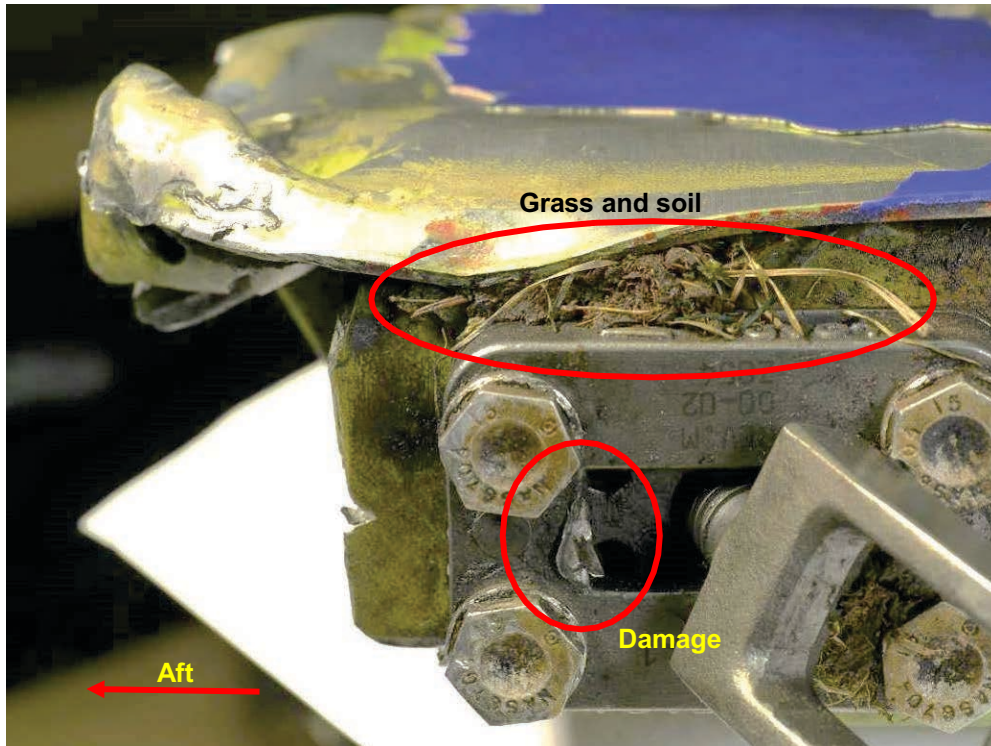


Figure 24: Aft latch keeper of inboard fan cowl fragment

Bent and folded skin, which appeared to be consistent with impact damage was found on the lower aft corner near the latch keeper; see Figure 25.



Figure 25: Lower aft corner of inboard fan cowl fragment

Approximately eight inches of the forward edge of the cowl fragment skin was folded outward; see Figure 26.



Figure 26: Forward edge of inboard fan cowl fragment

The forward lower corner of the fan cowl fragment was bent and folded, it also had evidence of soil on the surface; see Figure 27.



Figure 27: Forward lower corner of fan cowl fragment

Suspected Inlet Cowl Fragment

An overview of the packaging the suspected inlet cowl fragment arrived in is shown in Figure 28.



Figure 28: Inlet cowl fragment inside the packaging

The suspected inlet cowl fragment was reportedly found imbedded in the fixed leading edge of the left wing during the initial damage assessment of the aircraft in Philadelphia. The fragment was removed at the scene and delivered to EQA by the NTSB on May 20, 2018. The fragment was approximately three inches in length and two inches in width; see Figure 29.



Figure 29: Suspected inlet cowl fragment

Under direction of the NTSB, the suspected inlet cowl fragment was sent to BR&T for material identification.

Left Wing Leading Edge Slats

The slats are numbered one through four, with one being the outboard most slat, and increasing sequentially to four being the inboard most slat on the left wing. The majority of the damage found on all four of the slats was on and around the leading edge. All four of the slats had scratches and gouges which were consistent with an object sliding down the leading edge of the slats from inboard to outboard.

Slat No. 1

An overview of slat No. 1 is shown in Figure 30.



Figure 30: Overview of the upper surface of slat No. 1, with the outboard edge on the right of the image, and inboard edge on the left of the image

The data tag for slat No. 1 is shown in Figure 31.



Figure 31: Data tag for slat No. 1

There was evidence of material scrapping along the leading edge as well as above and below it. A gouge approximately five inches in length and a 0.25 inch in width was found between 18 and 23 inches away from the outboard edge; see Figure 32.

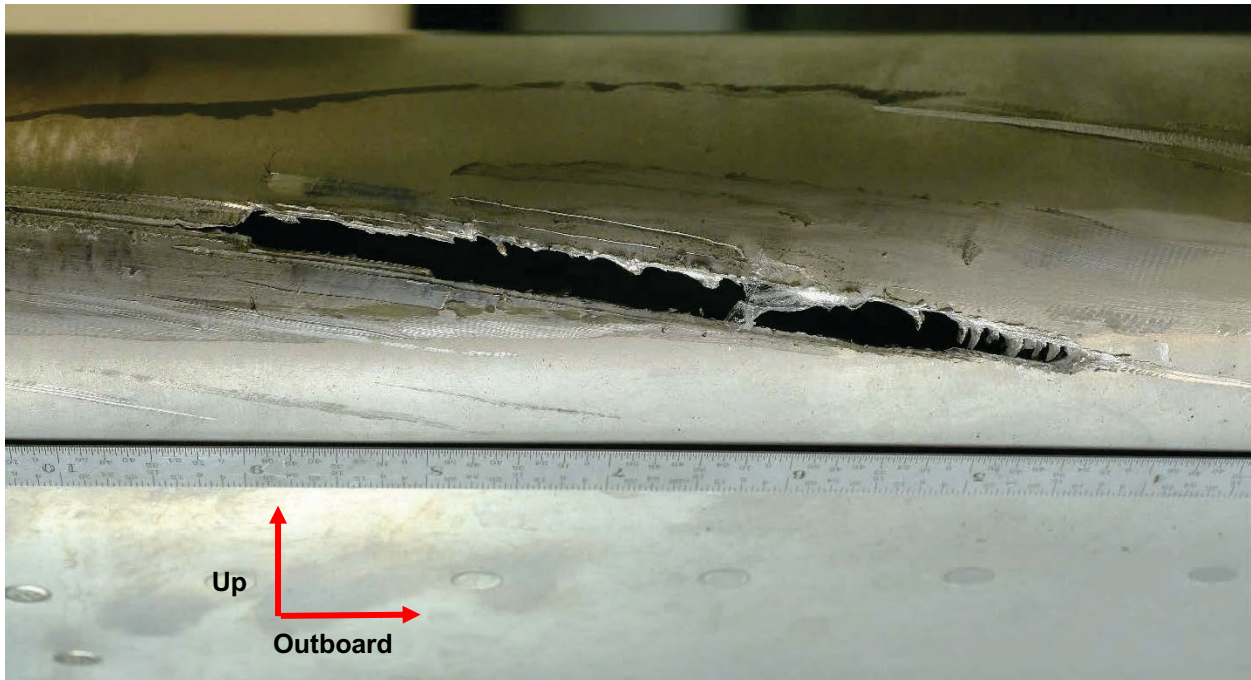


Figure 32: Gouge in the leading edge of slat No. 1, approximately between 18 and 23 inches from the outboard edge

The base of the vortex generator, located approximately 47.5 inches from the outboard edge, remained attached to the lower surface of slat No. 1; see Figure 33. The fin portion of the vortex generator was fractured and missing and the fracture surface was bent towards the outboard direction.



Figure 33: Vortex generator on the lower surface of slat No. 1, approximately 47.5 inches from the outboard edge
Slat No. 2

An overview of slat No. 2 is shown in Figure 34.



Figure 34: Overview of the upper surface of slat No. 2, with the outboard edge on the right of the image, and inboard edge on the left of the image

The data tag for slat No. 2 is shown in Figure 35.



Figure 35: Data tag for slat No. 2

There was evidence of material scrapping along the leading edge as well as above it and below it. The leading edge was semi-flattened and dented in the following locations (measurements in inches from the outboard edge): 37-67 inches, 74-90 inches, 92-97

inches, and 101-121 inches. Approximately 77 inches from the outboard edge, a vertical fracture approximately five inches in length, was present in the dented area of the leading edge; see Figure 36.

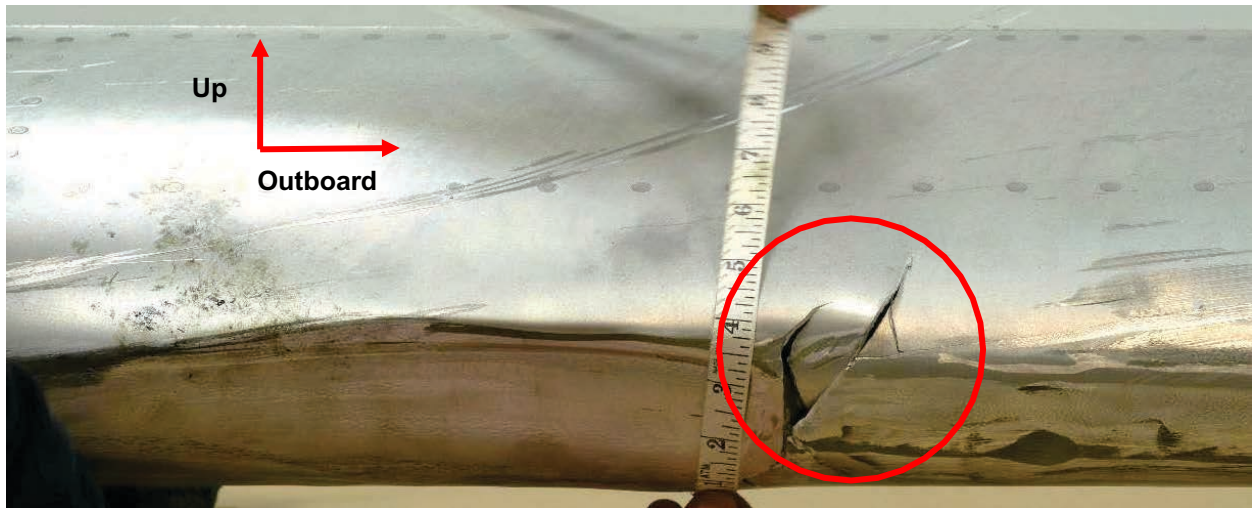


Figure 36: Vertical fracture approximately 77 inches from the outboard edge of slat No. 2

The base of the vortex generator, located approximately 21 inches from the outboard edge, remained attached to the lower surface of slat No. 2, with the fin section fractured and missing. The fracture surface of the vortex generator was bent toward the outboard edge; see Figure 37.

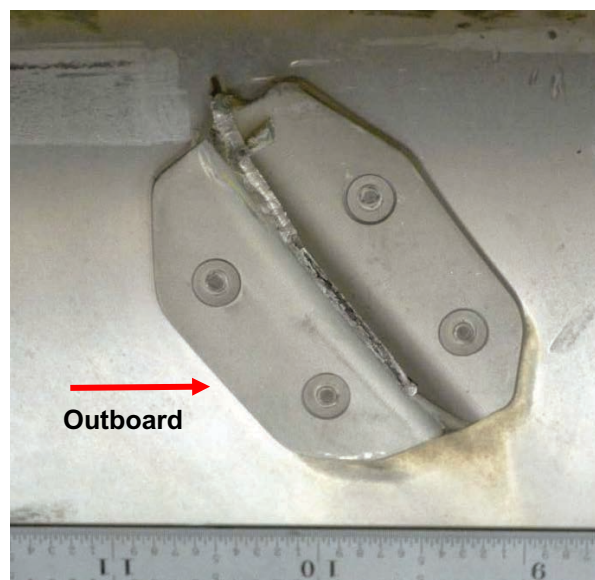


Figure 37: Vortex generator, approximately 21 inches from outboard edge on the lower surface of slat No. 2

The vortex generator, located approximately 101 inches from the outboard edge on the lower surface, was completely sheared off and missing; see Figure 38.

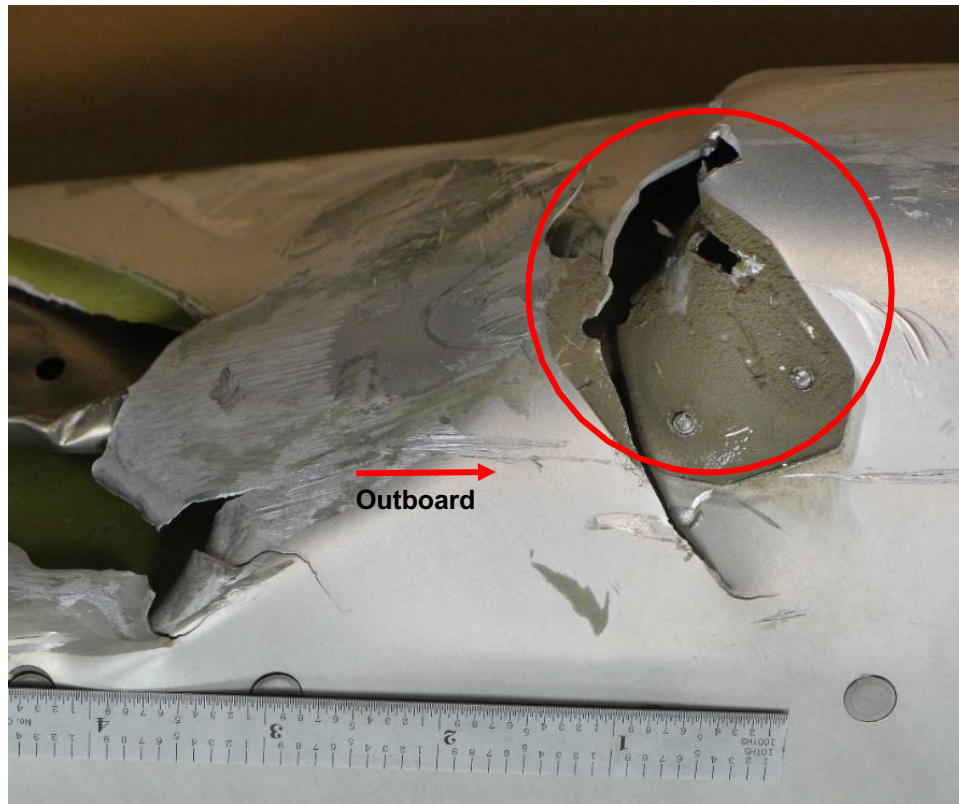


Figure 38: Approximately 101 inches from the outboard edge, where the vortex generator would have been located on the lower surface of slat No. 2

An area of leading edge located approximately from 101 to 117 inches from the outboard edge was fractured with skin material missing. The anti-ice system tubing was also exposed and crushed in the same area; see Figure 39.



Figure 39: Area of leading edge with missing skin material on slat No. 2

At approximately 121 inches from the outboard edge, on the upper surface, the trailing edge was damaged as well as an area of composite material approximately three inches forward of the trailing edge; see Figure 40.

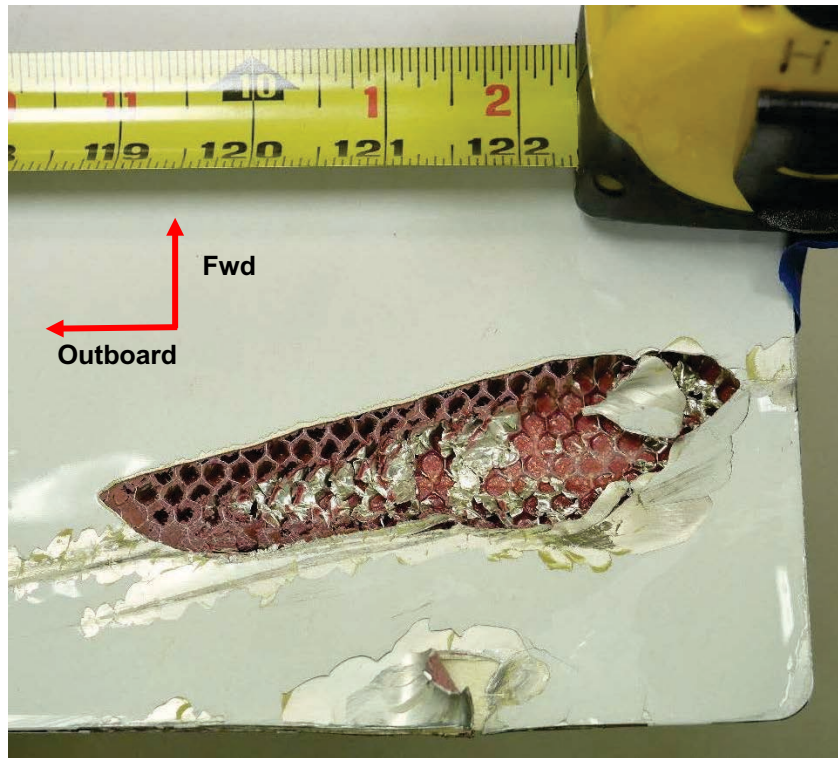


Figure 40: Upper surface trailing edge damage of slat No. 2

At approximately 103 inches from the outboard edge, on the lower surface trailing edge, a non-metallic panel, which covered a hinge point was damaged; Figure 41.



Figure 41: Lower surface trailing edge damage of slat No. 2

Slat No. 3

An overview of slat No. 3 is shown in Figure 42.



Figure 42: Overview of the upper surface of slat No. 3, with the outboard edge on the right of the image, and inboard edge on the left of the image

The data tag for slat No. 3 is shown in Figure 43.



Figure 43: Data tag for slat No. 3

There was evidence of material scrapping along the leading edge as well as above and below it. An area of leading edge located approximately 101 to 112 inches from the outboard edge, was fractured with skin material missing. The anti-ice tubing was also crushed in the same area; see Figure 44. During the initial examination of the aircraft after the incident, it was reported that a metal fragment was removed from this area, and packaged in the same box as the passenger windows. The metal fragment edges appeared to correspond with the fractured skin in the slat, see Figure 45. Under direction of the NTSB, the metal fragment was sent to BR&T for material analysis.

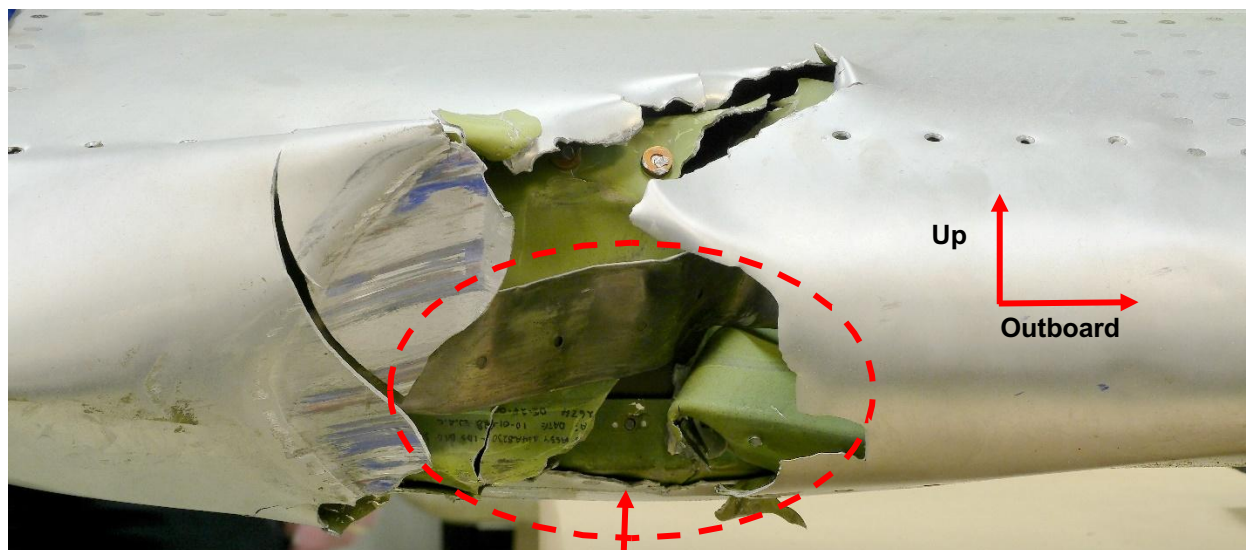


Figure 44: Fracture in slat No. 3 leading edge skin, approximately 101 to 112 inches from the outboard edge

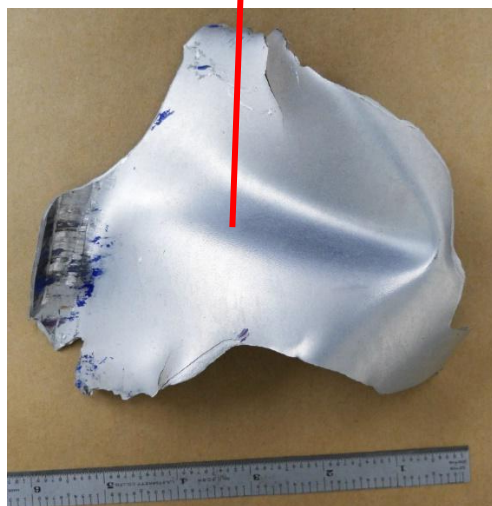


Figure 45: Slat No. 3 skin fragment

The damage located approximately 101 to 112 inches from the outboard edge was also evident on the trailing side of the slat; Figure 46.

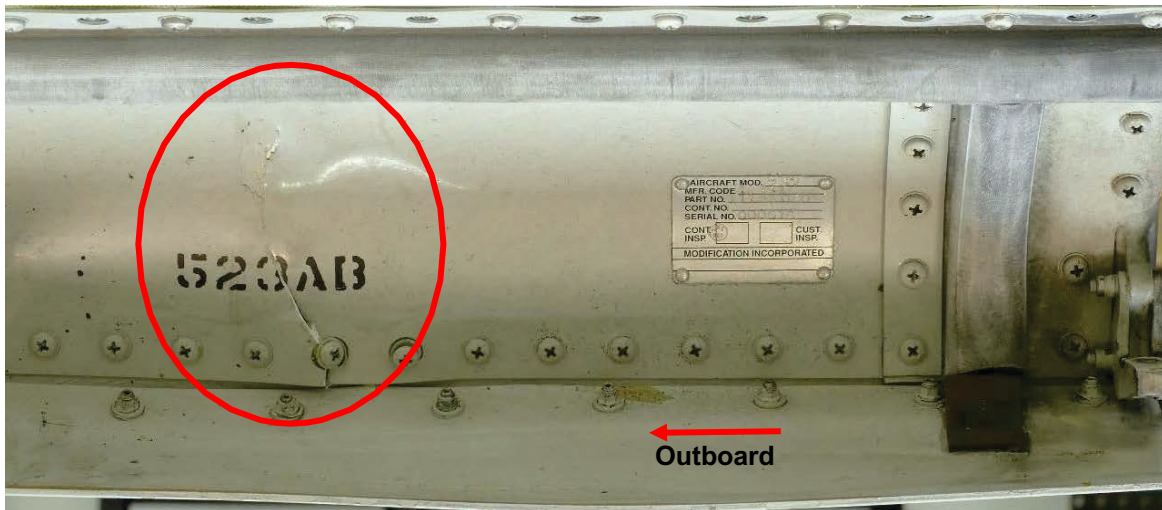


Figure 46: Slat No. 3 trailing side damage

A second area of damage to the leading edge, located approximately 38 to 72 inches from the outboard edge, was fractured. It measured about 34 inches in length and seven inches in width. The anti-ice tubing was also crushed in the area; see; Figure 47.



Figure 47: Leading edge damage on slat No. 3

Damage was found on the upper composite surface approximately 46 inches from the outboard edge; see Figure 48.

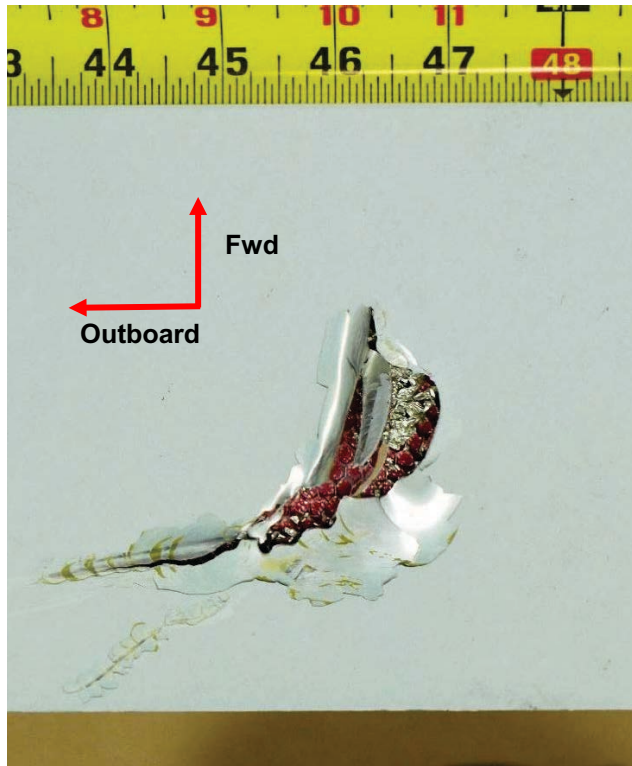


Figure 48: Upper surface damage on slat No. 3

A metal fragment approximately a 0.5 inch in length and a 0.25 inch in width, was found inside the leading edge about 101 inches from the outboard side; see Figure 49. Under direction of the NTSB, the fragment was sent to BR&T for material analysis.



Figure 49: Metal fragment found inside the leading edge of slat No. 3

Slat No. 4

An overview of slat No. 4 is shown in Figure 50.



Figure 50: Overview of the upper surface of slat No. 4, with the outboard edge on the right of the image, and inboard edge on the left of the image

The data tag for slat No. 4 is shown in Figure 51.



Figure 51: Data tag for slat No. 4

An area of leading edge located approximately between 94 and 109 inches from the outboard edge, was fractured with material missing creating a void, measuring about 14 inches in length and 9 inches in width. The anti-ice tubing in the area was crushed and severed. The forward edge of the nose beam was also punctured in the area behind the anti-ice tubing measuring about 5 inches in length and 5.5 inches in width.



Figure 52: Fracture in slat No. 4 skin and structure

ANALYSIS

BR&T used Fourier-transform infrared spectroscopy (FT-IR) for the organic analysis, and energy-dispersive X-ray spectroscopy (EDX) for the inorganic analysis of the nine samples of the grease-like substance that were taken during the initial damage assessment of the aircraft in Philadelphia. The BR&T analysis concluded that the nine samples were all comprised of the same compound. See enclosure A for more details.

BR&T used scanning electron microscope (SEM) analysis to identify any residual contaminants remaining on the outer window panes. Trace amounts of aluminum fragments, as well as carbon, oxygen and small amounts of silicon were found in the damaged area of the row 24 window and on the witness mark of the row 22 window. The aluminum trace fragments most closely match 7000 series aluminum, but an exact match was not possible due to the small particle size. No trace amounts of aluminum were found on the row 23 window, but trace amounts of carbon oxygen, silicon, and sulfur were present. See enclosure A for more details.

BR&T used SEM analysis to identify any residual contaminants remaining on the damaged aircraft skin section that was removed from above row 24. Only traces of primer were found. See enclosure A for more details.

BR&T used SEM and EDX analysis to identify the material of the suspected engine inlet cowl fragment that was found embedded in the skin of the left wing, aft of the number two slat. The analysis suggests that the fragment was a 2000 series aluminum alloy.

BR&T used SEM and EDX analysis to identify both of the metal fragments associated with slat No. 3. The analysis showed that the large fragment most closely matches 7000 series aluminum, and the smaller fragment aluminum alloy could not be identified. See enclosure A for more details.

DISPOSITION:

The three passenger window outer panes, row 24 skin section, two slat fragments, and inlet cowl fragment was delivered to BR&T for analysis on June 25, 2018. The three passenger window outer panes and row 24 skin section were returned to EQA on August, 20 2018. The two slat fragments and inlet cowl fragment were returned to EQA on August 27, 2018.

The fan cowl fragment was sent to a UTAS facility in Chula Vista, CA on June 6, 2018, per instructions from the NTSB.

The inlet cowl fragment was sent to a UTAS facility in Chula Vista, CA on September 10, 2018, per instructions from the NTSB.

The remaining subject component are secured at the Boeing EQA facility in Seattle, WA, awaiting disposition from the NTSB.

The preceding information is being submitted for information purposes.

Signature on file.

ENCLOSURE:

A. SWA1380 737 Chemical Analysis DCA18MA142



SWA1380 737 Chemical Analysis DCA18MA142

Sample Summary

The following samples were analyzed for chemical composition.

Skin Sample #1 (btw Window) – Swab Sample

Skin Sample #2 (btw Window) – Swab Sample

Skin Sample #3 (btw Window) – Swab Sample

Below Window #1 – Swab Sample

Below Window #2 – Swab Sample

Engine Sample #1 Fan Cowl – Swab Sample

Engine Sample #2 Fan Cowl – Swab Sample

Fan Cowl Sample #1 – Swab Sample

Fan Cowl Sample #2 – Swab Sample

Exterior Skin (rear) #1 – Skin Panel (cut down in size for analysis)

Window Pane Covering #1 – Window Pane Row 24 ABC (cut down in size for analysis)

Window Pane Covering #2 – Window Pane Row 23 ABC (cut down in size for analysis)

Window Pane Covering #3 – Window Pane Row 22 ABC (cut down in size for analysis)

Slat #3 Fragment (large)

Slat #3 Fragment (small)

Fragment of inlet cowl assembly

Location images for samples

Sample ID for analysis:

Skin Sample #1 (btw Window)

Skin Sample #2 (btw Window)

Skin Sample #3 (btw Window)



Swab
Samples

Below Window #1

Below Window #2



Swab
Samples

Engine Sample #1 Fan Cowl

Engine Sample #2 Fan Cowl

Fan Cowl Sample #1

Fan Cowl Sample #2

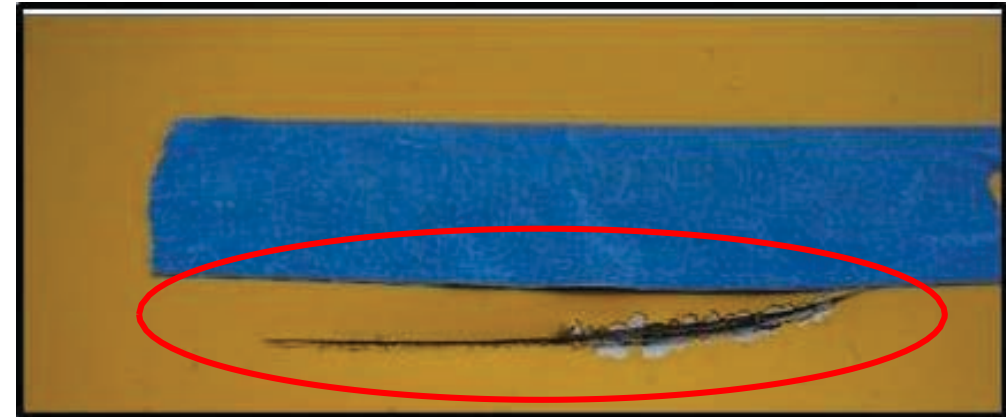
No location
images
provided –
Swab
Samples



Location images for samples

Sample ID for analysis:

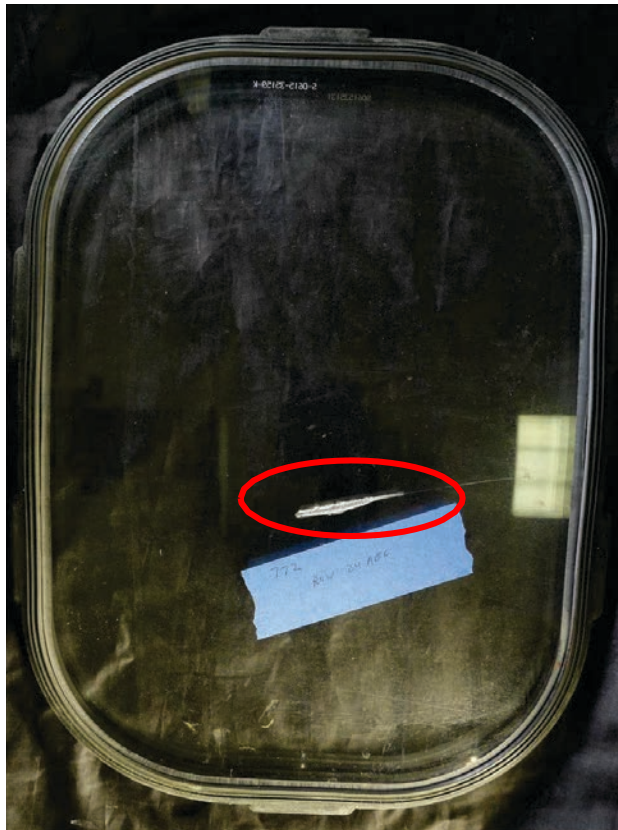
Exterior Skin (rear) #1



Location images for samples

Sample ID for analysis:

Window Pane Covering #1 –
Window Pane Row 24 ABC
(cut down in size for analysis)



Window Pane Covering #2 –
Window Pane Row 23 ABC
(cut down in size for analysis)



Window Pane Covering #3 –
Window Pane Row 22 ABC
(cut down in size for analysis)



Location images for samples

Sample ID for analysis:

Slat #3 Fragment (large)



Slat #3 Fragment (small)



Fragment of inlet cowl assembly



Summary - Swab Samples

Samples

Skin Sample #1 (btw Window) – Swab Sample

Skin Sample #2 (btw Window) – Swab Sample

Skin Sample #3 (btw Window) – Swab Sample

Below Window #1 – Swab Sample

Below Window #2 – Swab Sample

Engine Sample #1 Fan Cowl – Swab Sample

Engine Sample #2 Fan Cowl – Swab Sample

Fan Cowl Sample #1 – Swab Sample

Fan Cowl Sample #2 – Swab Sample

Summary

FT-IR (Organic analysis) and EDX (Inorganic analysis) were used to compare the 9 swab samples.

Slides 11-16 show a virtually identical match to each other in both organic and inorganic analysis.

The residue samples on these 9 swabs are the same compound.

Summary - Skin Panel

Samples

Exterior Skin (rear) #1 – Skin Panel (cut down in size for analysis)

Summary

SEM analysis was used to identify any contaminants left on the surface of this exterior skin panel.

No Metallic fragments were found in this aluminum skin sample – only traces of Carbon, Oxygen, and Silicon Slide 17

Summary - Window Pane Covering

Samples

Window Pane Covering #1 – Window Pane Row 24 ABC (cut down in size for analysis)

Window Pane Covering #2 – Window Pane Row 23 ABC (cut down in size for analysis)

Window Pane Covering #3 – Window Pane Row 22 ABC (cut down in size for analysis)

Summary

SEM analysis was used to identify any contaminants left in the window pane “gouged surfaces”

Window Pane #1 and Window Pane #3 both showed trace amounts of Aluminum fragments. Also present is Carbon, Oxygen, and small amounts of Silicon (window covering base materials) - The Aluminum trace fragments most closely match the 7000 Series. An exact match is not possible due to the small particle size. – Slides 18 and 20

Window Pane #2, had no trace evidence of Aluminum fragments – Slide 19

Summary - Metal Pieces

Samples

Slat #3 Fragment (large)

Slat #3 Fragment (small)

Fragment of inlet cowl assembly

Summary

EDX analysis was used to identify the base metal.

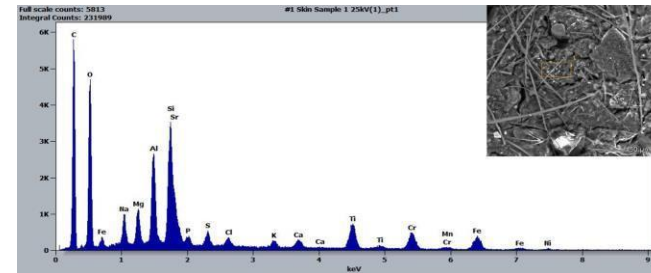
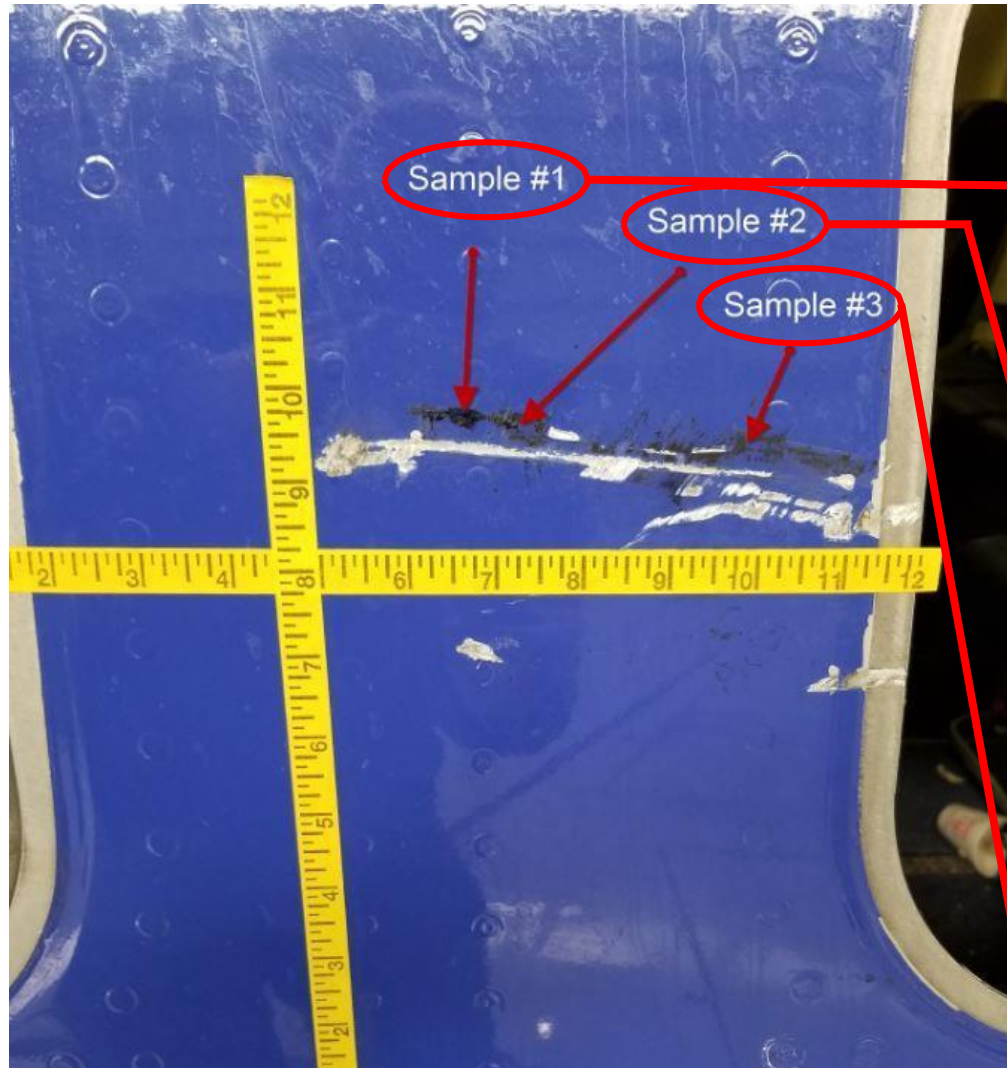
Slat #3 Fragment (Large) is a series 7xxx aluminum alloy. - Slide 21

Slat #3 Fragment (Small) is an aluminum alloy but the series was not identified - Slide 22 (SEM was used for this sample)

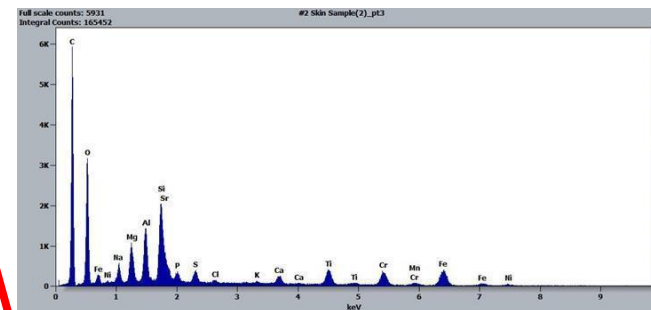
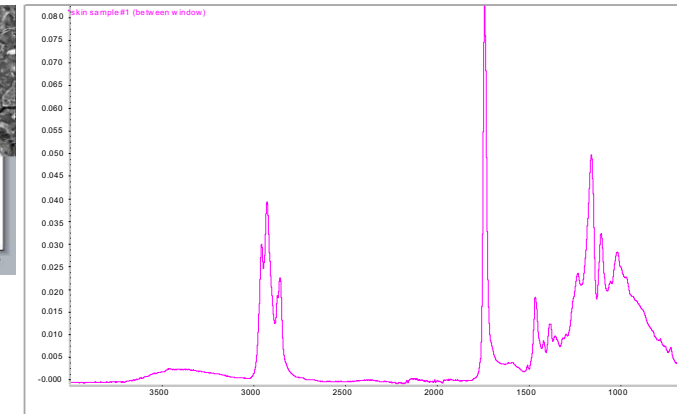
Fragment of inlet cowl assembly is a series 2xxx aluminum alloy. - Slide 23

Data

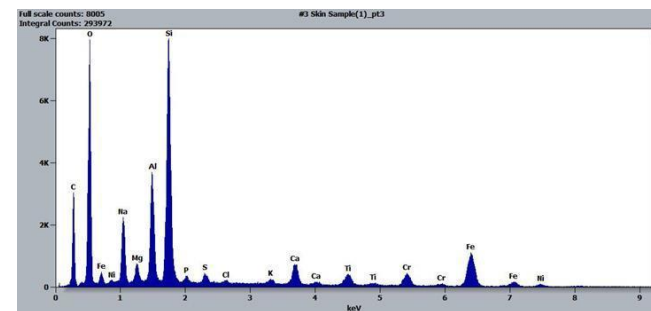
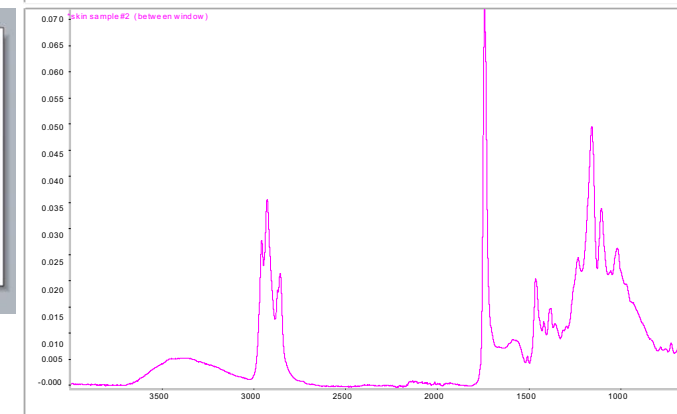
Sample Location ID Swab Samples



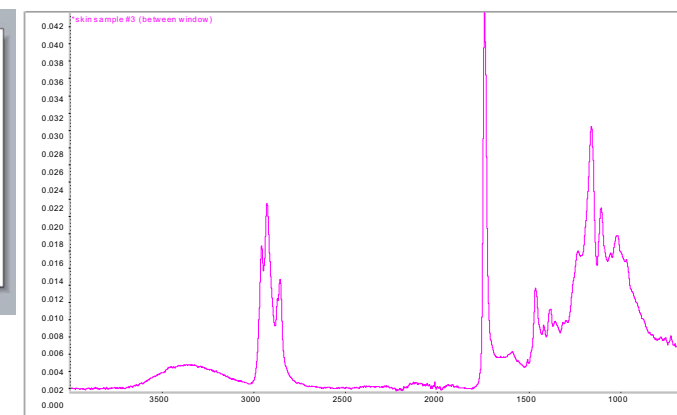
Skin Sample #1 (btw Window)



Skin Sample #2 (btw Window)

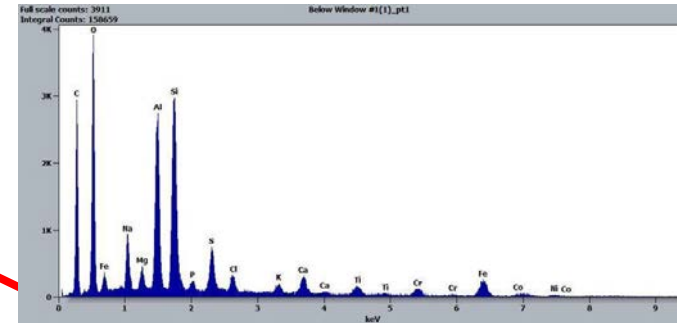


Skin Sample #3 (btw Window)

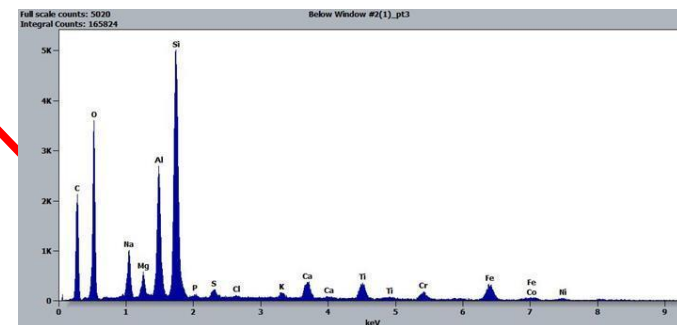
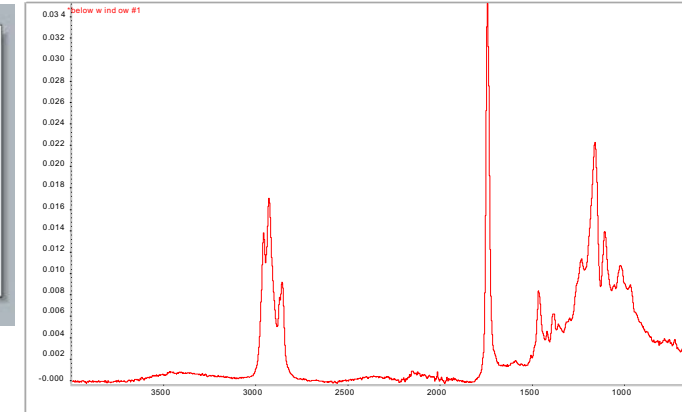


Data

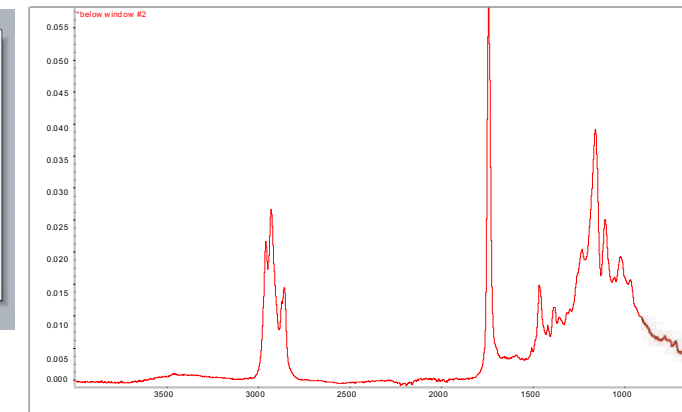
Sample Location ID Swab Samples



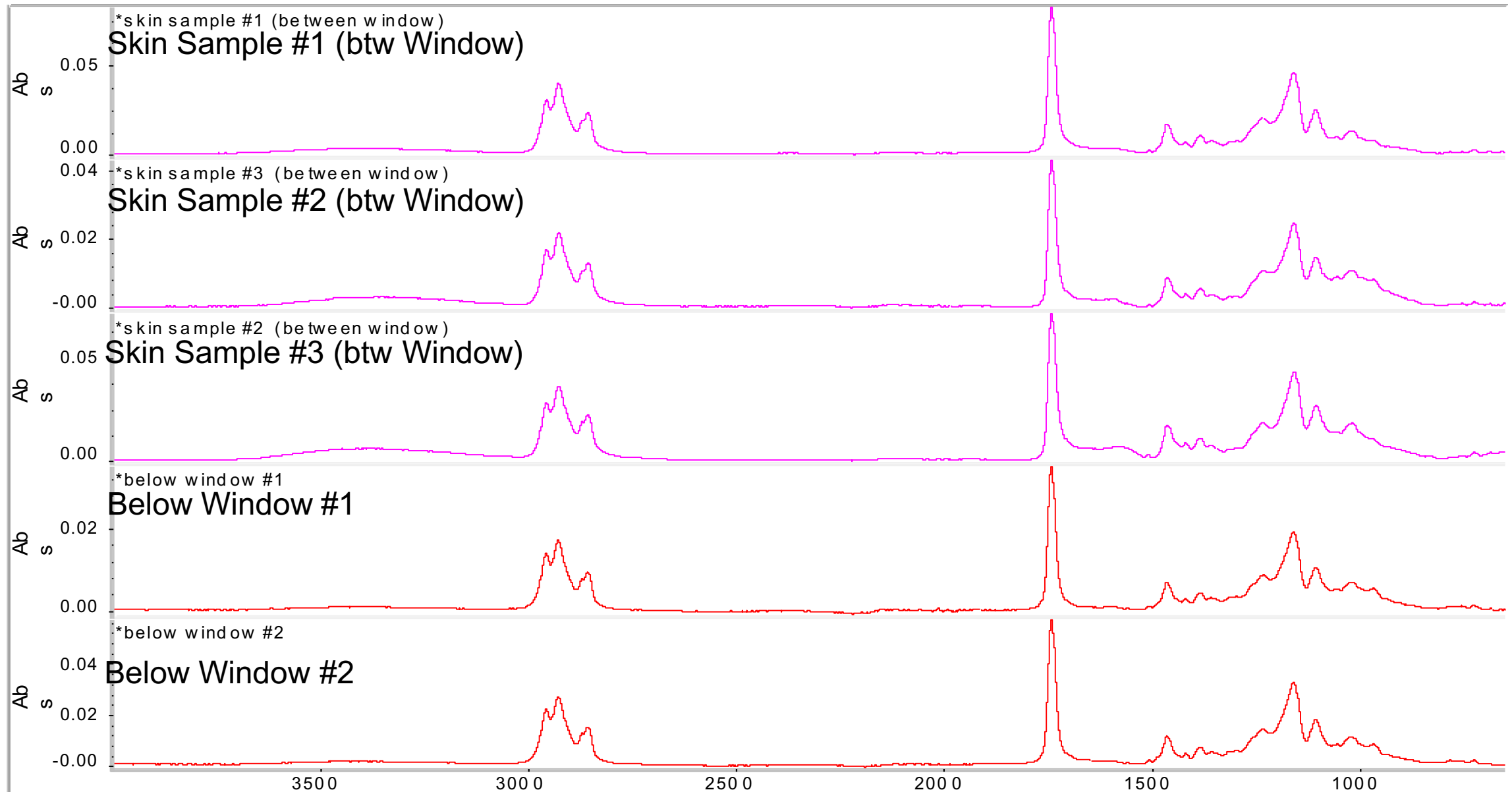
Below Window #1



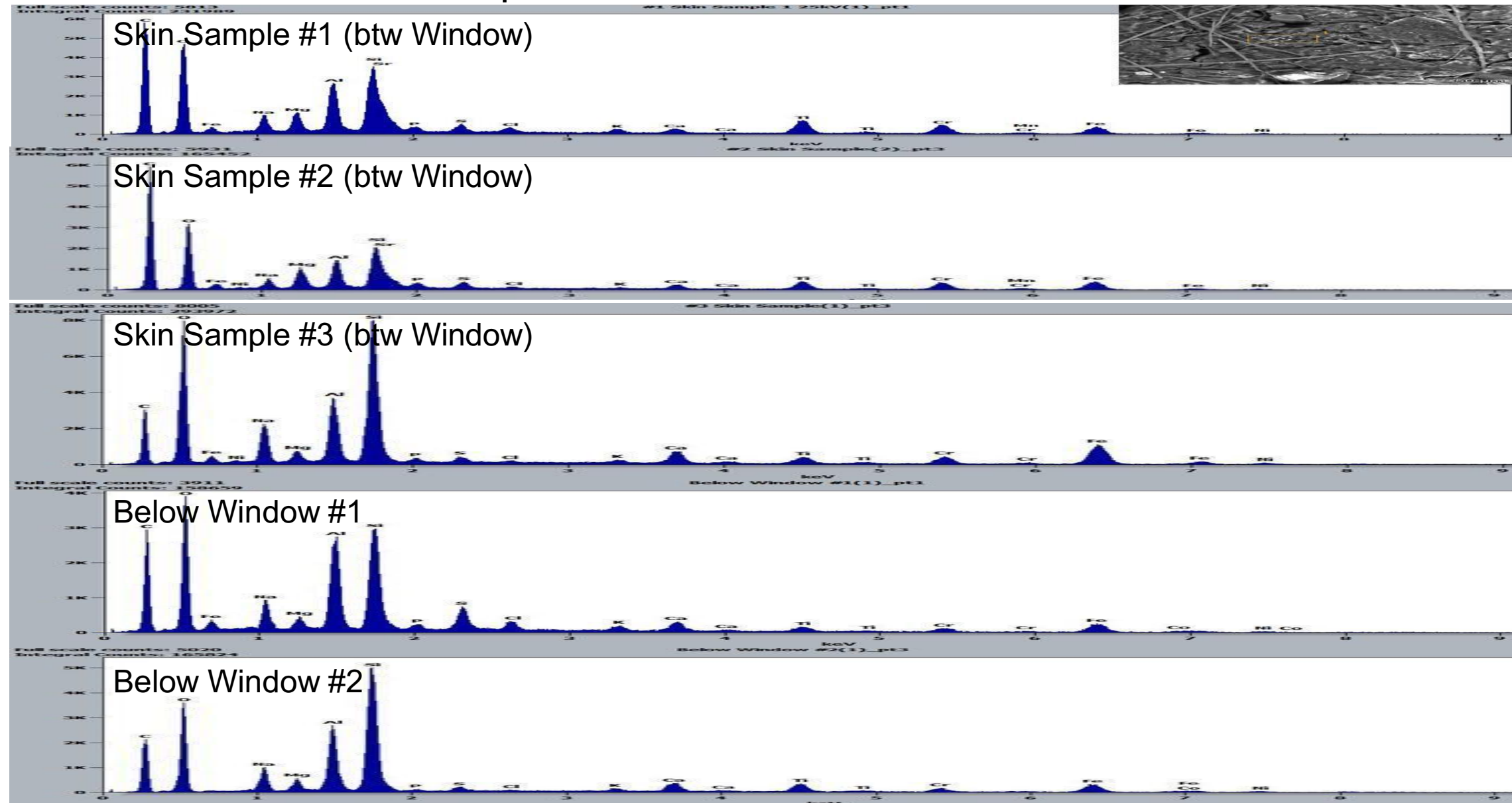
Below Window #2



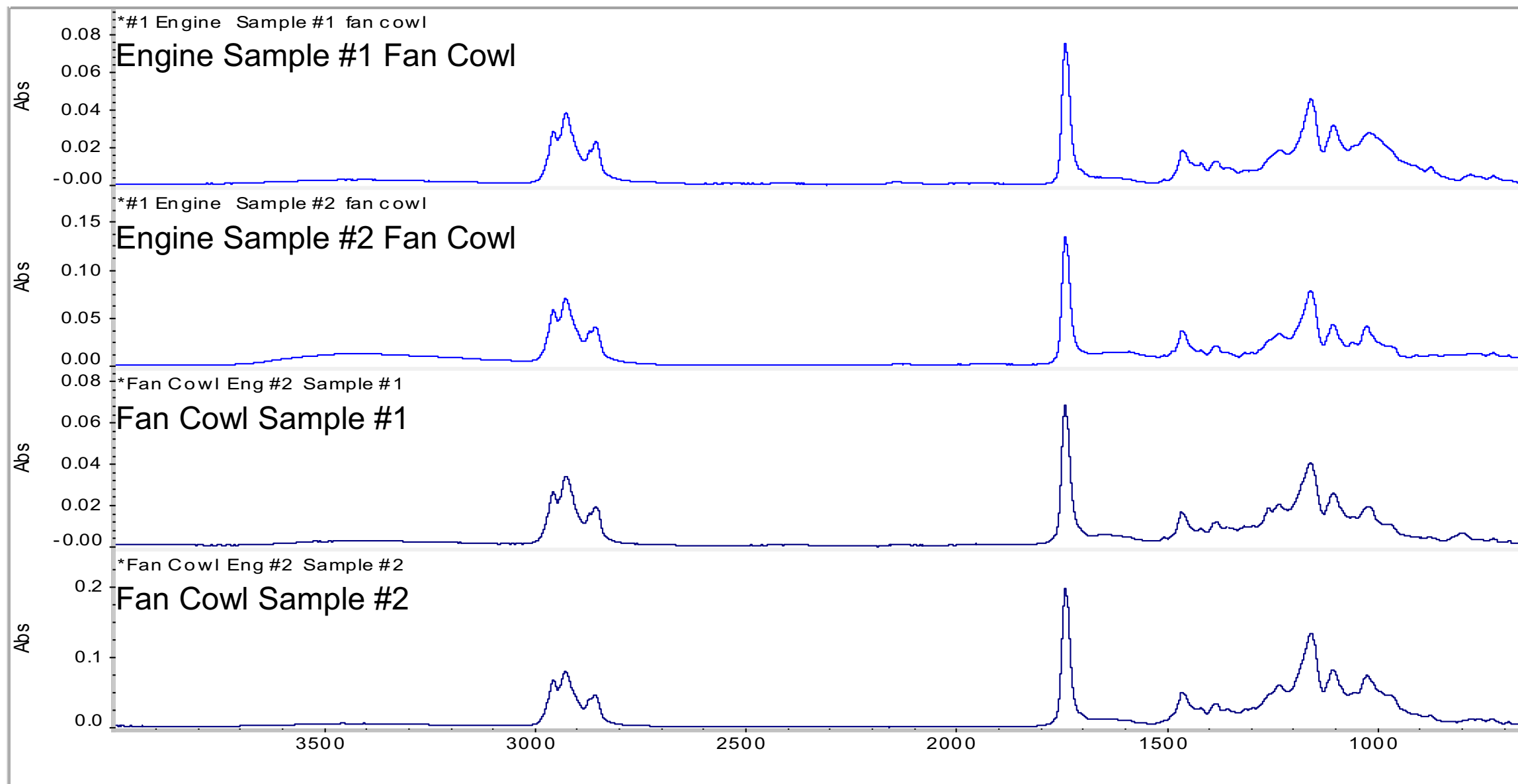
FT-IR Data ALL Swab Samples



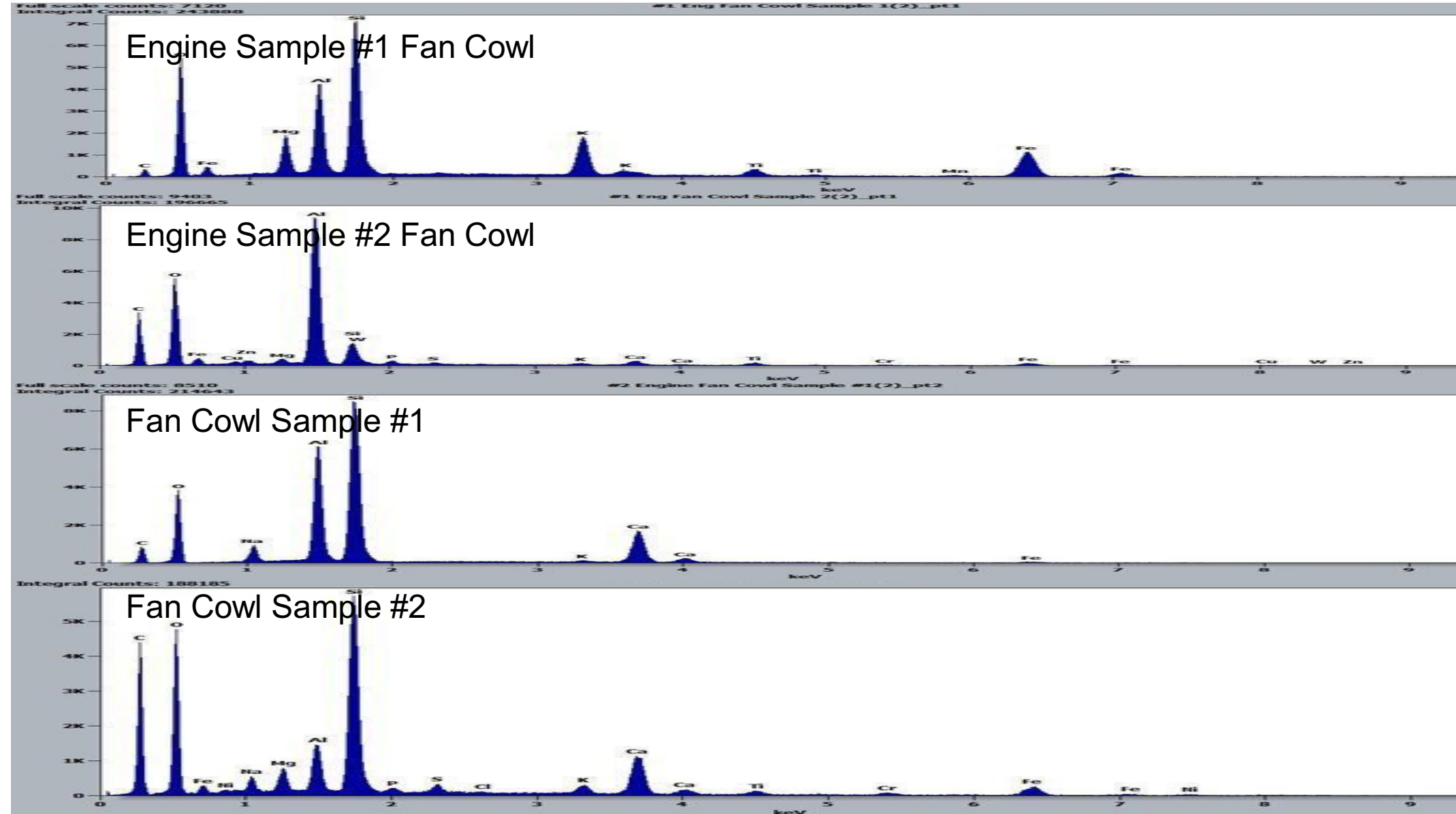
EDX Data ALL Swab Samples



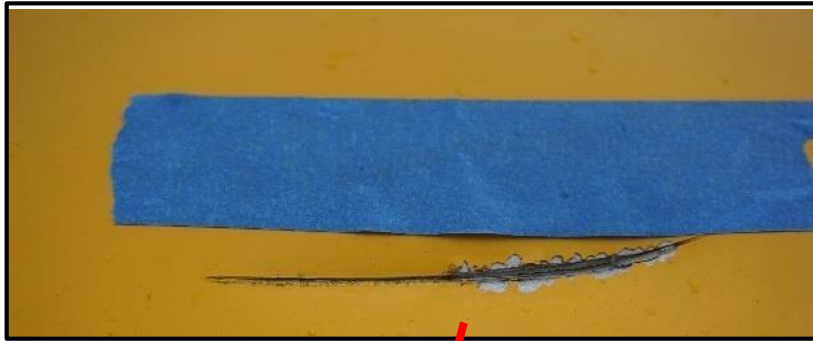
FT-IR Data ALL Swab Samples



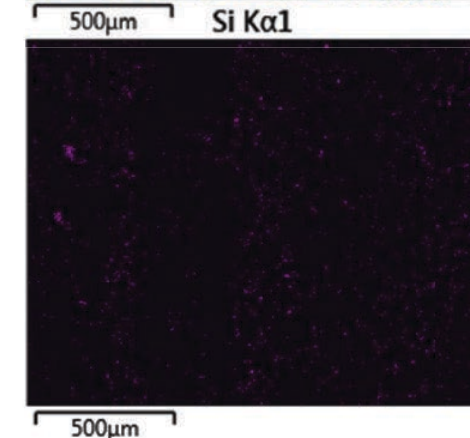
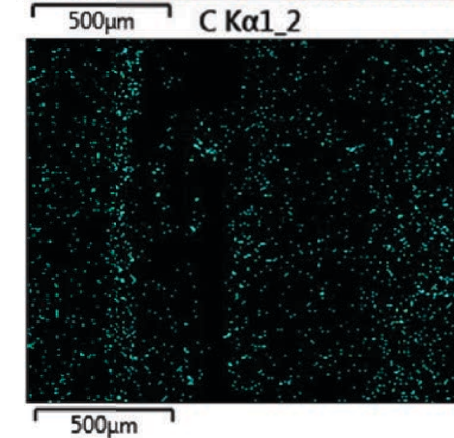
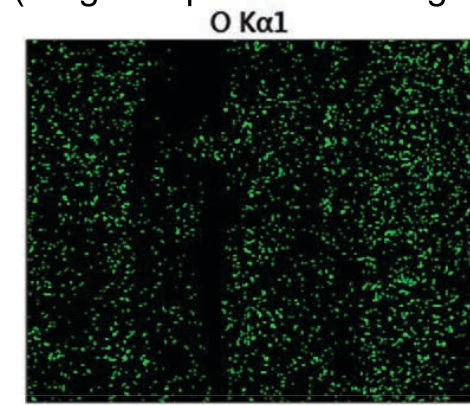
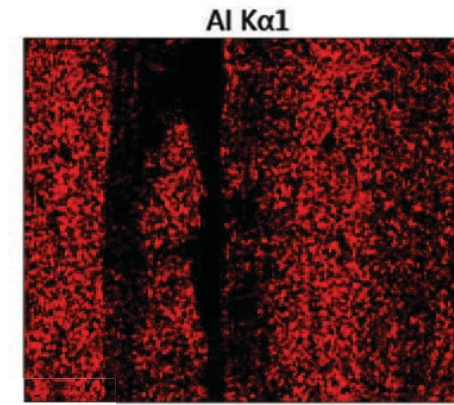
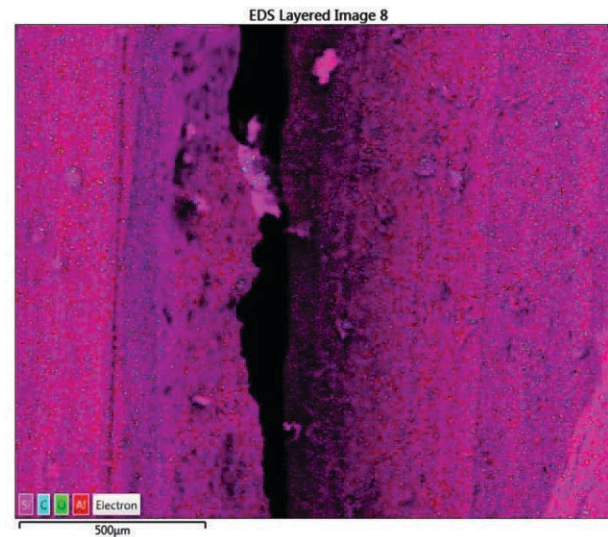
FT-IR Data ALL Swab Samples



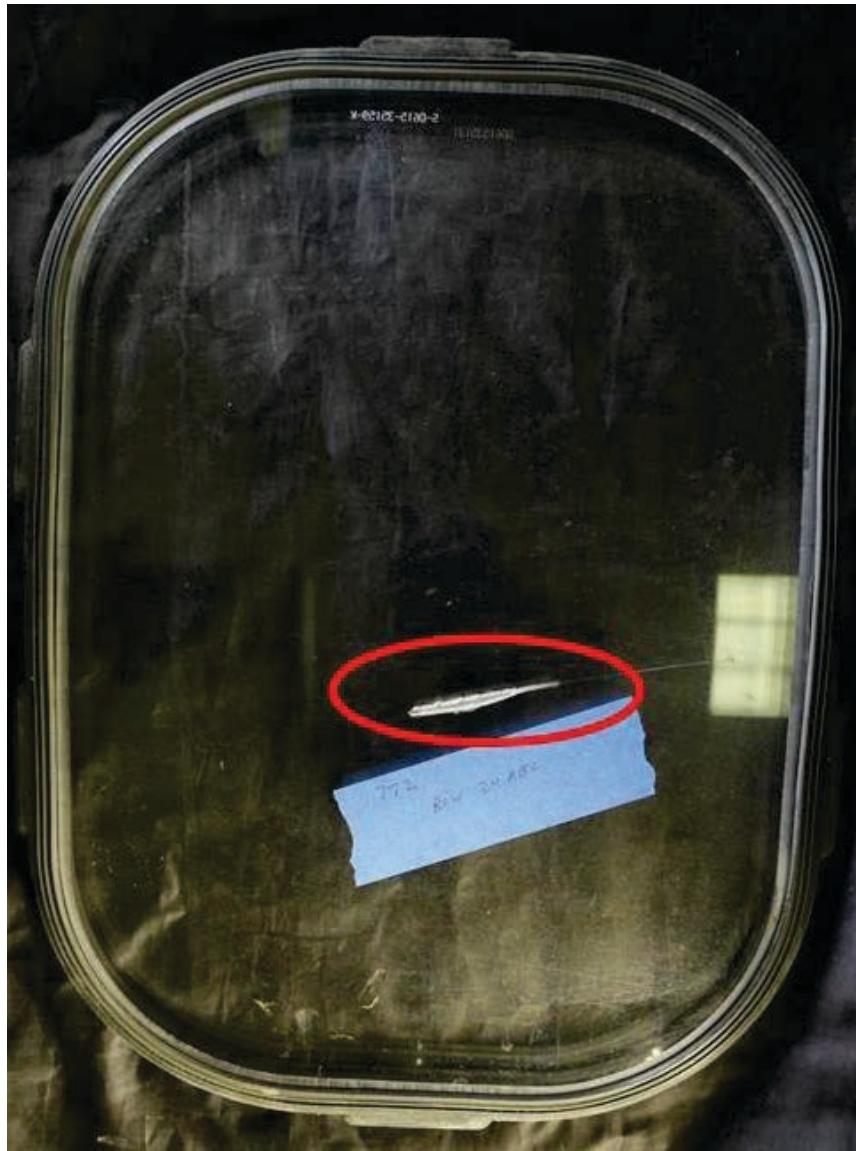
SEM Imaging – looking for metallic deposit on **Exterior Skin Rear #1** (Single Represented Image)



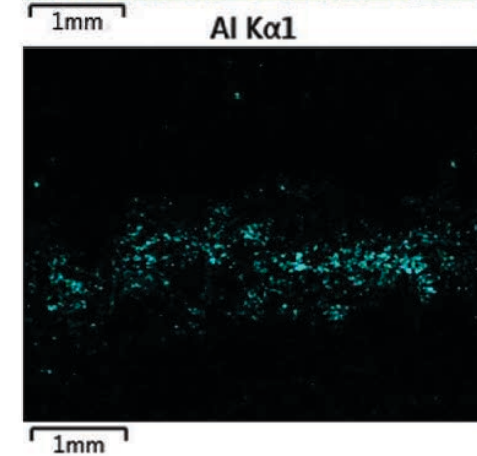
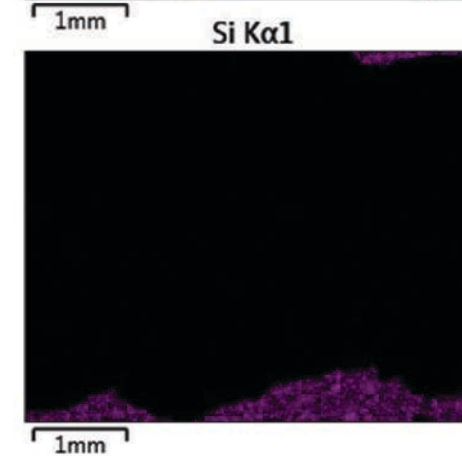
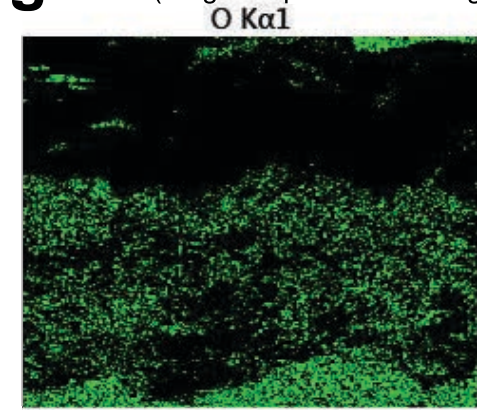
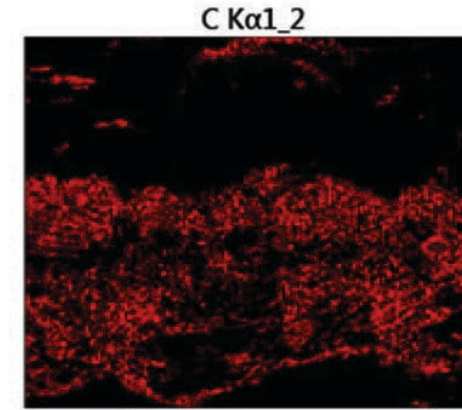
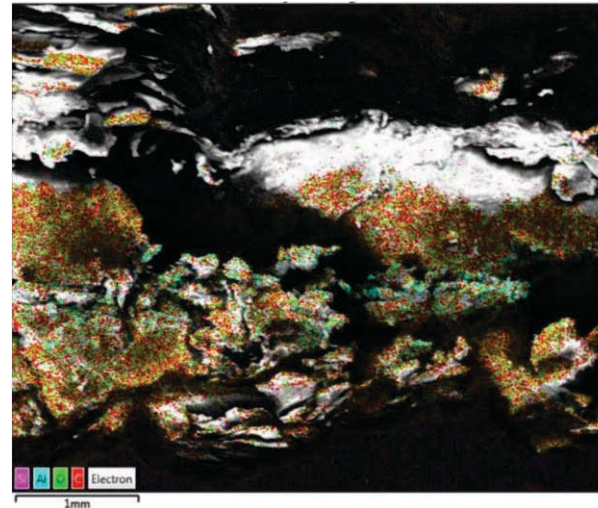
No Metallic fragments were found in this aluminum skin sample – only traces of Carbon, Oxygen, and Silicon



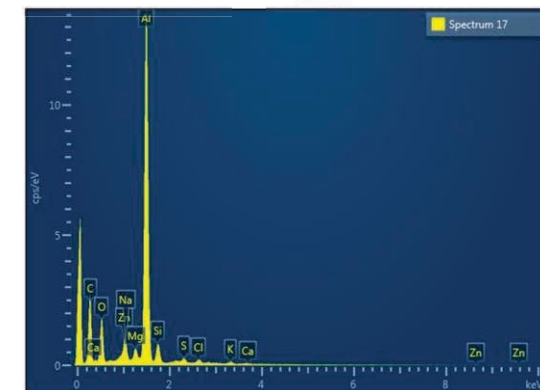
SEM Imaging – looking for metallic deposit in **Window Pane Covering #1** (Single Represented Image)



Trace amounts of Aluminum fragments were found in this sample. Also present is Carbon, Oxygen, and small amounts of Silicon



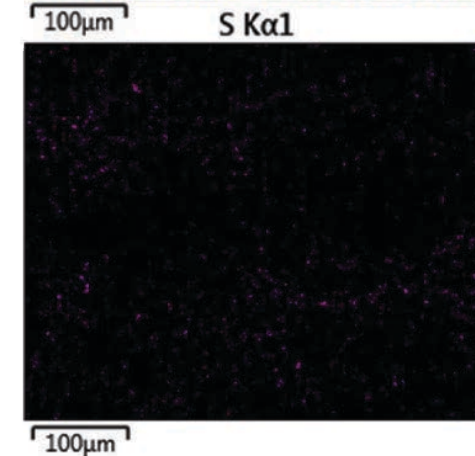
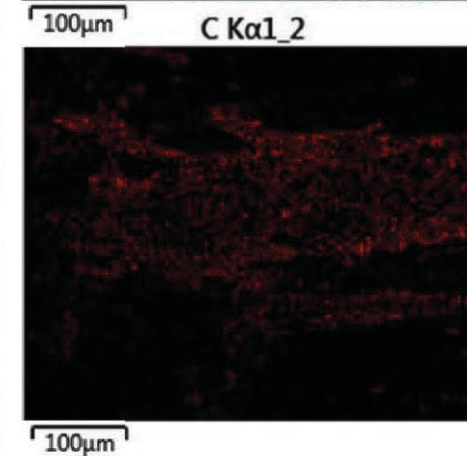
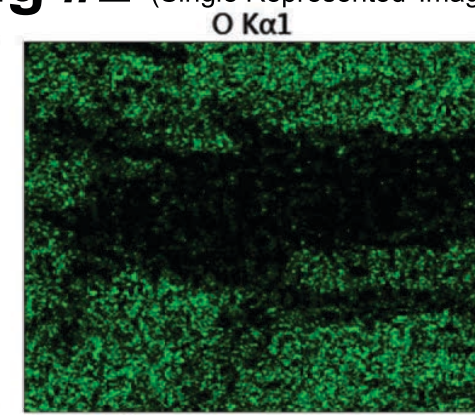
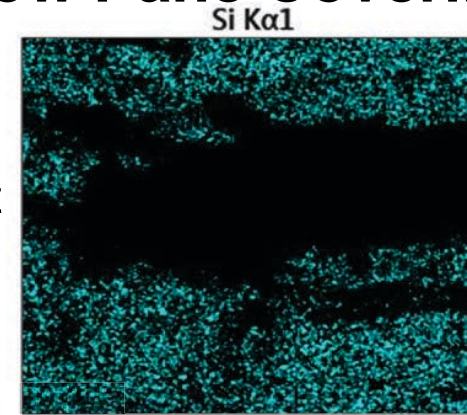
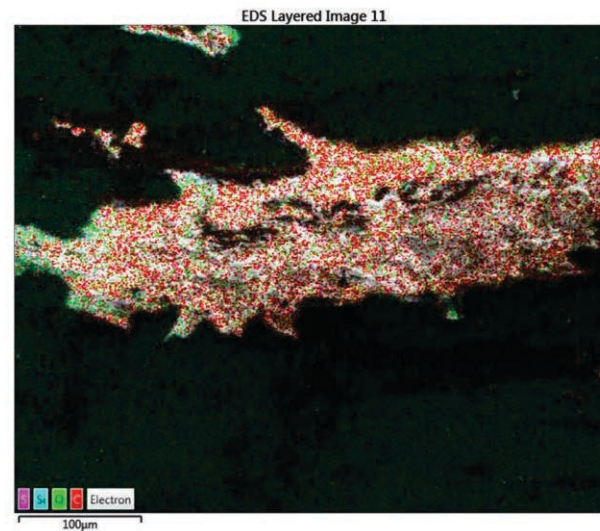
The Aluminum trace fragments most closely match the 7000 Series. An exact match is not possible due to the small particle size.



SEM Imaging – looking for metallic deposit in **Window Pane Covering #2** (Single Represented Image)



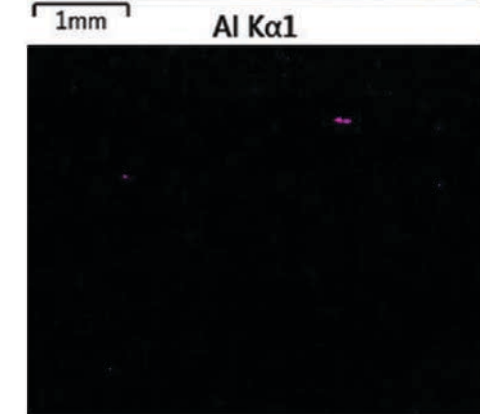
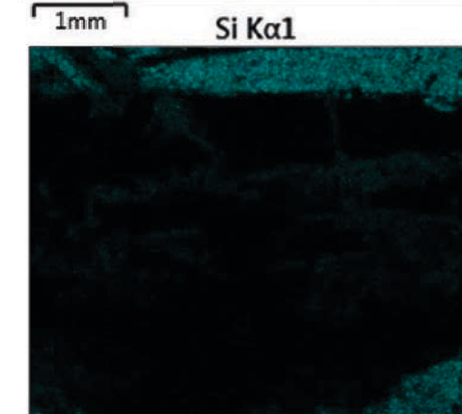
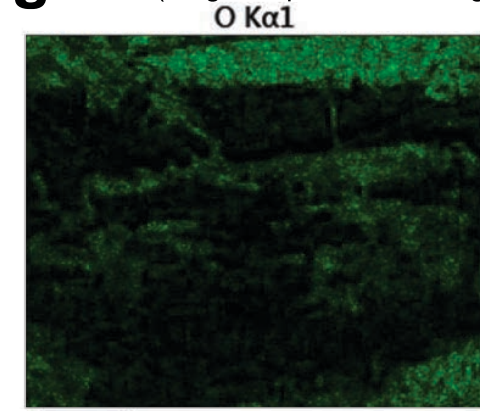
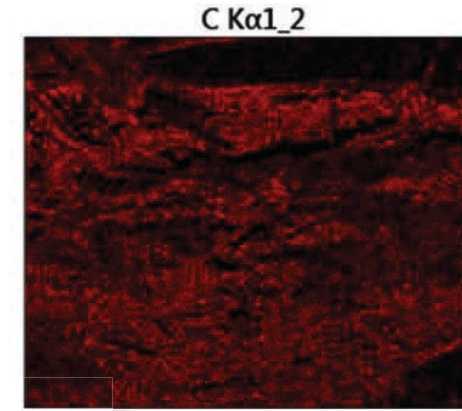
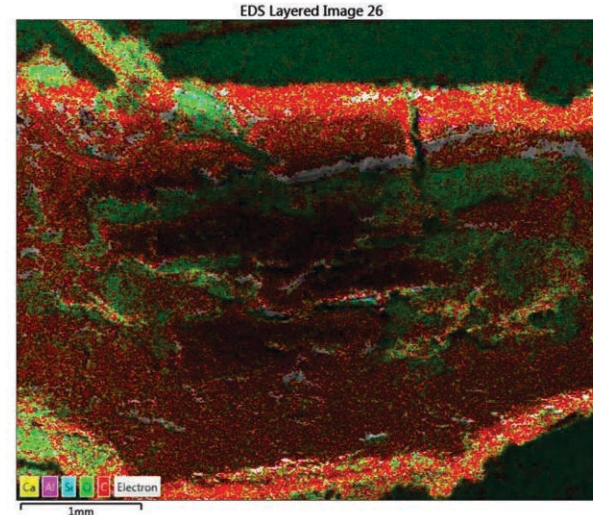
No trace amounts of Aluminum fragments were found in this sample. Present is Carbon, Oxygen, Silicon, and Sulfur



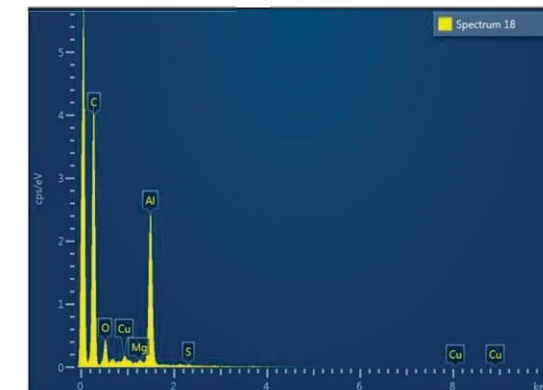
SEM Imaging – looking for metallic deposit in **Window Pane Covering #3** (Single Represented Image)



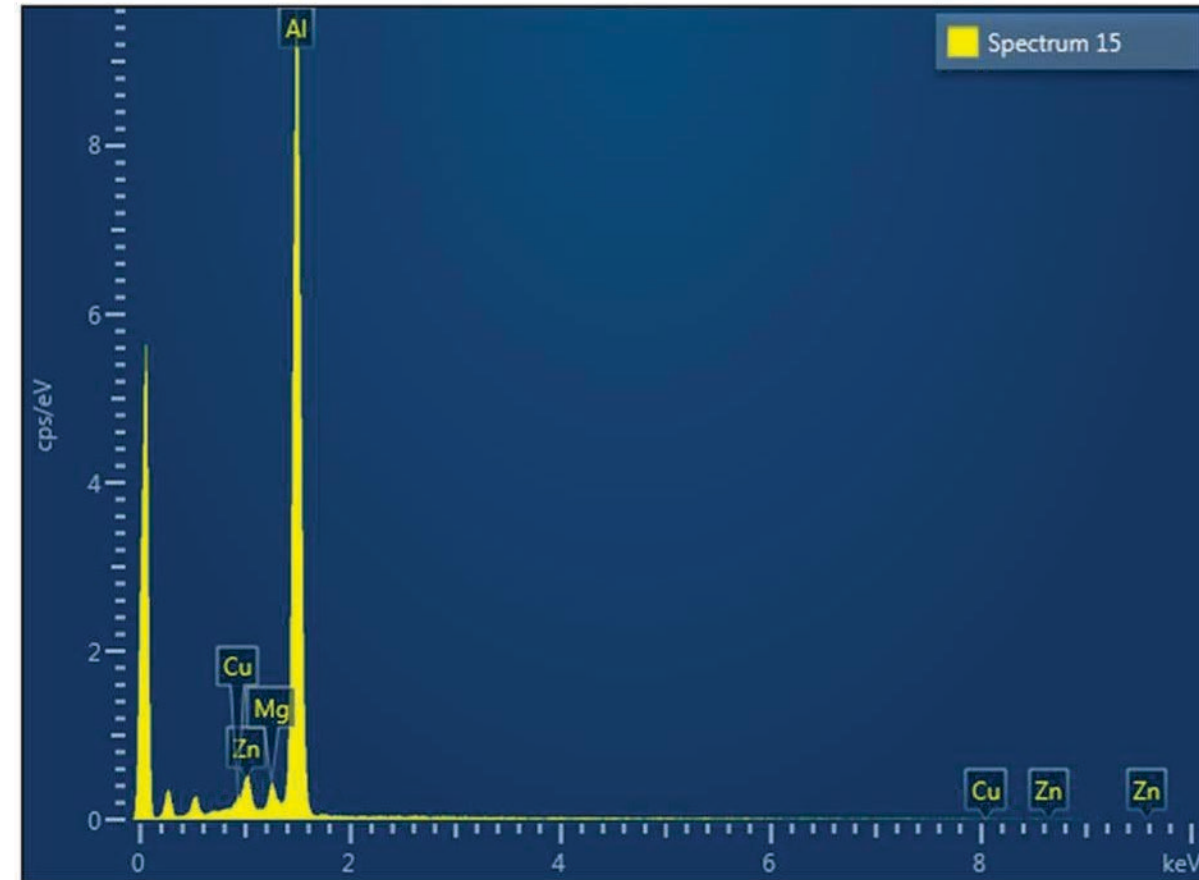
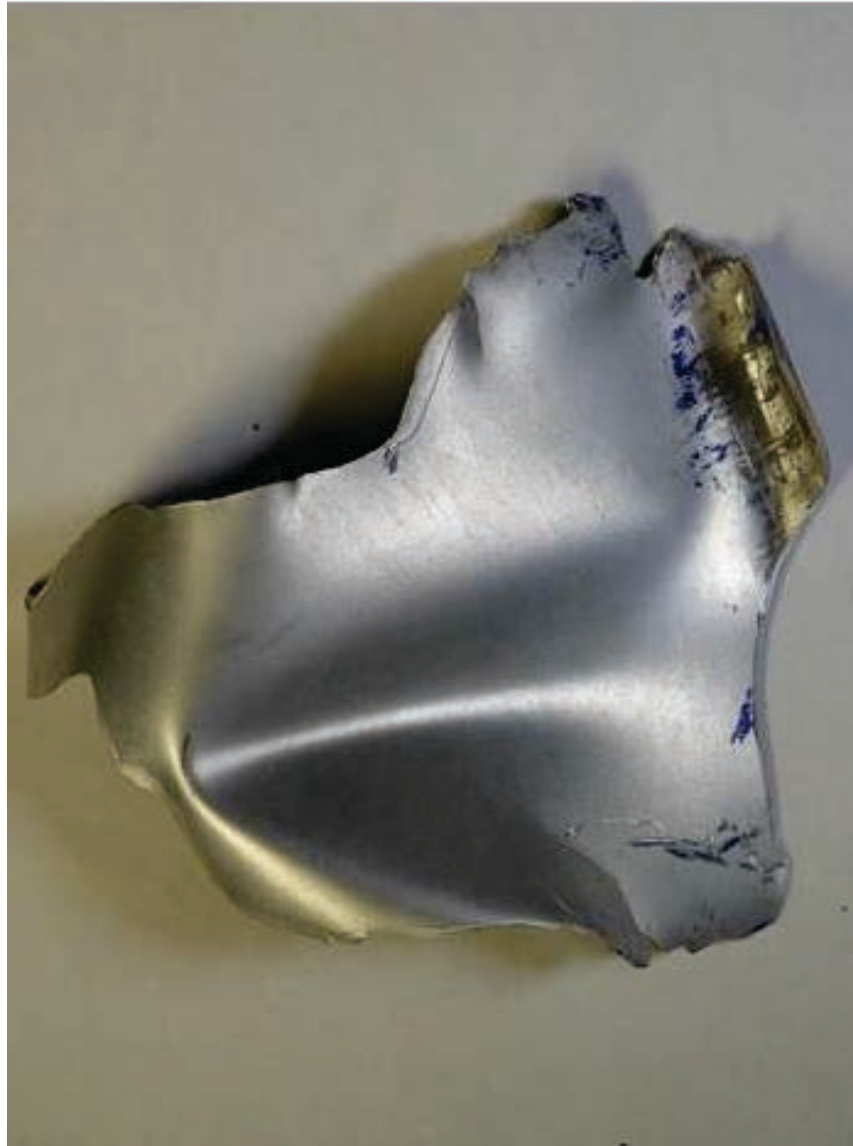
Trace amounts of Aluminum fragments were found in this sample. Also present is Carbon, Oxygen, and small amounts of Silicon



The Aluminum trace fragments most closely match the 7000 Series. An exact match is not possible due to the small particle size.



EDX Analysis – looking for metal composition **Slat #3 Fragment (Large)** (Single Represented Image)



Element	Wt%	Wt% Sigma
Mg	2.55	0.18
Al	88.80	0.60
Cu	2.11	0.46
Zn	6.54	0.43
Total:	100.00	

SEM Analysis - looking for metal composition **Slat #3 Fragment (Small)** (Single Represented Image)



Slat #3 Fragment (small)(2)

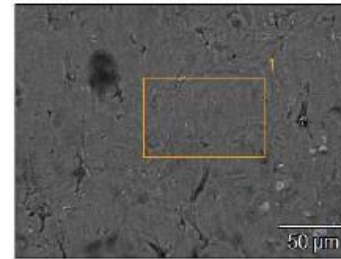
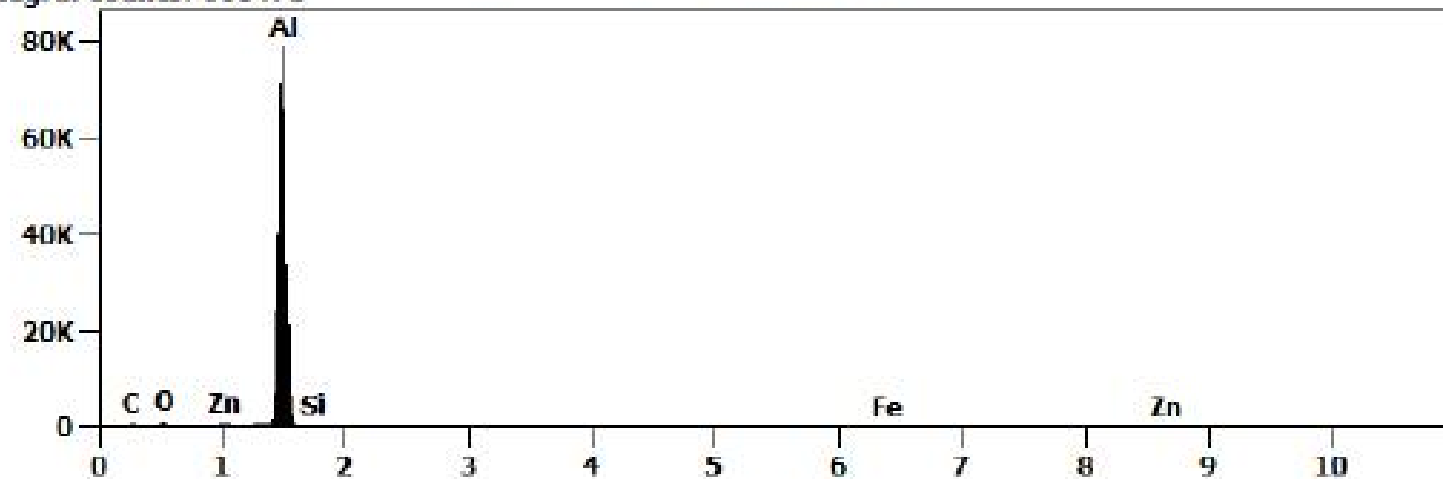


Image Name: Slat #3 Fragment (small)(2)
Image Resolution: 1024 by 768
Image Pixel Size: 0.24 μm
Acc. Voltage: 20.0 kV
Magnification: 500

Full scale counts: 78811
Integral Counts: 680471

Slat #3 Fragment (small)(2)_pt1



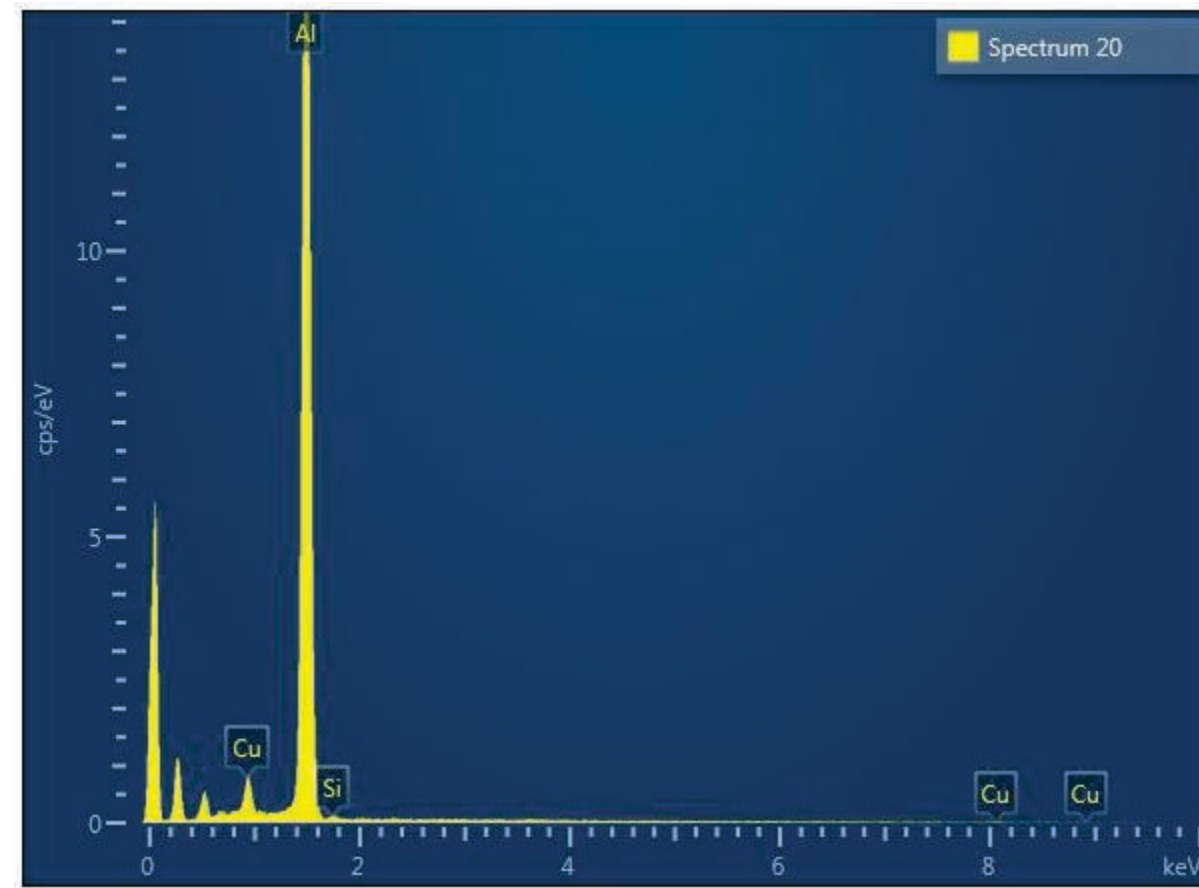
Weight %

	Al	Si	Fe	Zn
Slat #3 Fragment (small)(2)_pt1	97.93	0.55	0.28	1.23

Atom %

	Al	Si	Fe	Zn
Slat #3 Fragment (small)(2)_pt1	98.81	0.54	0.14	0.51

EDX Analysis - looking for metal composition **Fragment of inlet cowl assembly** (Single Represented Image)



Element	Wt%	Wt% Sigma
Al	93.72	0.26
Si	0.44	0.11
Cu	5.84	0.24
Total:	100.00	